

**STUDIES ON THE UTILIZATION OF FILLED MILK  
FOR THE PREPARATION OF  
INDIGENOUS MILK PRODUCTS  
[KHOA & CHHANA]  
AND THEIR SWEETS  
[PEDA & SANDESH]**

**(THESIS SUBMITTED FOR THE AWARD OF THE DEGREE OF DOCTOR OF  
PHILOSOPHY OF THE UNIVERSITY OF ALLAHABAD)**

**THESIS**

by

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## **CERTIFICATE OF ORIGINAL WORK**

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**"STUDIES ON THE UTILIZATION OF FILLED MILK  
FOR THE PREPARATION OF  
INDIGENOUS MILK PRODUCTS [KHOA & CHHANA]  
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The thesis attached hereto-entitled "**STUDIES ON THE UTILIZATION OF FILLED MILK FOR THE PREPARATION OF INDIGENOUS MILK PRODUCTS [KHOA & CHHANA] AND THEIR SWEETS [PEDA & SANDESH]**". Prepared and submitted by Mr. Arif Albrecht Broadway, in fulfillment of the requirement of the Degree of Doctor of Philosophy, is hereby accepted.

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# CHAPTER - I

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Introduction

## INTRODUCTION

In the present times of economic crisis in almost all the part of world, it is no wonder everybody concerned with the situation - directly or indirectly, often talks about the necessity of greater efficiency in our use of available resources. Food crisis, which is the most important problem in developing countries like India, dictates that for maximum economic returns from any industrial operations, nothing that can be made use of, should be wasted. And the dairy industry is no exception.

Effective utilization of by-products is one of the major aspects of economizing the dairy processing operation just as for any other food products processing activity. Milk itself being a unique wholesome food, anything that is lost from it, is a loss from the point of view of not only nutritive value but also its economical significance.

The major by-products available with our dairy industry are skim milk, buttermilk and whey. Skim milk is simply milk from which fat has been removed. It sometimes has the undeserved reputation of being watered down in the nutrient category. Owing to negligible fat content, calories are much less, but other nutrients except fat-soluble vitamins remain virtually the same.

Manufacture of certain food products from the by-products is one of the ways in which the by-products utilization has been sought. Not only a great deal of work has been done on this aspect in the advanced countries, but quite a lot is being commercially practiced there. (Patel *et. al*, 1983)

Moreover, India produces largest quantity of world's groundnut oil, during the year 1978-79 it was 6.387 million tonnes (The Times of India, Directory and yearbook, 1982). The annual skim milk production in India is about 1338 million kgs (Srinivasan & Anantakrishnan, 1964). Therefore, a combination of these two ingredients have significant value in economy and in meeting nutritional requirement in manufacturing filled products of dairy industry in our country.

The quantities of the by-products available for use poses a big problem, one solution to this problem lies in manufacturing new products in combination with certain non-dairy product. In other words an amalgamation of dairy with non-dairy products.

Amongst a number of possible non-dairy ingredients especially of vegetable origin soyabean, groundnut oil, vanaspati oil (dalda) etc. are used (Patel *et. al*, 1983).

The cost of these vegetable fats is almost half the price of butterfat. These vegetable oils can be easily and successfully replace the milk fat for the preparation of filled milk and filled milk products.

Although the main roles of fat in diet is to supply energy it has lately acquired considerable attention of scientists throughout the world in respect of intake of saturated fatty acids excess of which may lead to dreadful diseases like atherosclerosis.

Epidemiological and laboratory studies have suggested that subjects consuming diets high in saturated fats may have increased risk of developing coronary heart disease. This has restricted the sale of dairy products containing milk fats in many developing countries. The growing health consciousness among the consumers of dairy products has called for the production of products rich in Poly-Unsaturated Fatty Acid (PUFA). The PUFA content of the dairy products can be increased by addition of select vegetable oils as partial replacement of milk fat. This is likely to enhance the nutritional quality of the traditional products.

The cost of milk fat is approximately twice as high as vegetable oils. In a country where the individual earning capacity is limited this has an important bearing. In addition, on the basis of data published by WHO (1965), Sweden, Finland (1968) and James (1973) milk fat has been considered as a possible risk factor in causing coronary heart disease (CHD). Keys *et al.* (1957A) observed that high dietary fat intake shortens clotting time of blood. High intake of fat increases risk of heart attack because of the high proportion of saturated fats in the diet. Many nutritionists believe that if fat intake is reduced to provide less than 30 percent of the calories through fats and oils, dietary fat would not be a risk factor at all in heart disease.

In contrast, most of the vegetable fats and oils used for consumption are more unsaturated than animal fats and also they contain no cholesterol. In view of the increasing occurrence of coronary complications there is considerable interest to reduce/replace the milk fat in yogurt with vegetable fat/oil.

Such products will be comparatively cheap and within the purchasing power of the weaker section of the consumers who normally cannot purchase milk and milk products. The basic premise of developing imitation and fabricated foods is to provide adequate nutrition to a large segment of the needy population in a cost-effective manner (Chakraborty, 1985).

The total milk production in our country is far from sufficient resulting in high cost and low per capita consumption. The predominant vegetarian population of the country should depend mainly on milk and milk products for supply of good quality proteins. But, the cost of whole milk and its products more or less are beyond the purchasing power of weaker sections. It is therefore quite natural and logical to explore possibilities of tailoring cheaper substitutes for milk and milk products. Filled milk and its products hold great promises in solving the twin problem of scarcity of milk and high prices of milk and milk products.

Moreover, the increase in milk production is not proportionate to the increase in human population. Hence, it is difficult to expect any substantial reduction in the cost of milk and milk products in foreseeable future. Therefore, a large quantum of fluid milk cannot be diverted towards preparation of milk product, which are beyond the purchasing power of weaker section of society. Realizing this, development and marketing of low cost milk product, based on cheaper ingredients such as vegetable fat, dairy by-products, vegetable proteins etc. will be of great significance in this country.

Fabricated foods are foods that have been taken apart and put together in a new form. Designed, engineered or formulated with ingredients, they may or may not include additives, vitamins and minerals. Some of the most important fabricated foods are snacks, cookies, prepared cereals, vegetable protein products and dietetic foods which have a special application for body builders, undernourished children, pregnant or lactating women. Formulated and engineered foods are some of the best examples of this type.

**Inglett (1975)** defined "**Fabricated foods**" as foods that have been designed, engineered, or formulated from various ingredients including additives.

**Dairy analogues** or substitutes for milk and milk products are generally categorized either as imitation products, i.e. products obtained by using sodium or calcium caseinate as the basic protein are based on non-dairy protein ingredients. Fats normally used in such formulations are mostly of vegetable origin. **Filled dairy products** in which only butterfat has been replaced by vegetable fats are also included in dairy analogues. **Filled milk products** refer to those products, which are made by combining fats or oils other than milk-fat, with milk solids. The milk solids may be in the form of skimmed, evaporated or condensed skim milk powder.

Filled milk and filled products contain fat from non-milk origin and all the non-fat ingredients of milk. **Hedrick (1969)** referred to filled products as those in which a part or all milk fat is replaced by vegetable fat.

Development of dairy products with vegetable oils and fats offer advantages of low cholesterol content, low raw material prices, uniform quality without seasonal change, high degree of security for supply, neutral taste and on shelf-life. The oils used for the manufacture of dairy products are mainly from Soya, coconut, cottonseed, groundnut and sunflower. A particular vegetable fat is selected according to factors such as availability, price, and resistance to oxidation and also nutritional and physiological conditions. Hydrogenated vegetable oils are less susceptible to oxidation because of lower levels of polyunsaturated fatty acids. However, oxidation only exists in the event of any separation of fat from the processed cheese-like product. Vegetable fats do not have any adverse effect on flavour though butterfat makes a more positive contribution. An Egyptian study showed that PC made with vegetable fats contained more unsaturated fatty acids than those made with milk fat (**El-Sonbaty et al., 1998**).

It is estimated that more than 50% of milk production is utilized for the manufacture of various Indian milk products and delicacies by traditional sector i.e. **Hulwais. (Banerjee, 1977)**. The value of khoa and chhana produced in India is probably twice the value of milk handled by the organized sector. Most of the traditional Indian dairy products are prepared normally in the small batches. Since no standard methods are adopted for their manufacture, the chemical, sensory and rheological properties of traditional dairy products are invariably inconsistent. The small-scale entrepreneurs and confectioners, who are largely engaged in the manufacture of those products, are unaware of emerging trends in production, preservation and overall quality control. Thus most of the traditional dairy products have limited shelf life.

More than 36 indigenous products are prepared in India today. Some of them confine to some region only. Account to available statistics, nearly 47% of total milk produced in India is converted to various dairy products. The breakup being Ghee(32.7%), Dahi(7.8%), Khoa(5.3%) and items like Chhanna, Paneer etc.,(1.2%).

One major milk product is khoa, obtained by rapidly evaporating milk in shallow pans to a sticky mass, which can be preserved for several days.

It is used in different kinds of traditional mithai such as peda, burfi and gulab jamun. Some 9 lakh tonnes of khoa valued at Rs.4500 crores is produced in the country. Yet another milk product of significance is chhana, a product of acid coagulation of hot milk and draining out of whey. This forms the base for sweets such as rasogollas and sandesh. Approximately, 12 lakh tonnes of chhana valued at Rs.600 crores is produced in India.

The value of Khoa and chhana produced is probably twice the value of all milk handled by the organized sector in the country. The value of Khoa and chhana-based sweets could possibly exceed Rs.13.000 crores. **(The Hindu Newspaper - 2000)**

The traditional milk products are the products of masses being made in India since time immemorial. These products have great social, religious, cultural, medicinal and economic importance. However, these products offer several technological mass appeal, cost of production, manufacturing technique, low-grade energy sources and requirement of low infrastructure and operational overhead cost and upliftment of the rural people of mass employment and improvement in the economical and nutritional status.

Indigenous products including the sweetmeats are capable of becoming such novelty products provided we are able to improve the hygienic and keeping quality of these products. A knowledge of physico-chemical attributes of these traditional products and effect of different factors influencing the same may contribute a great deal to enable the dairy technologists to produce these products in the organised sector under hygienic environment with better quality and longer shelf-life.

Milk and milk products formed the principal ingredients of food of Vedic Indians. Khoa based sweets have been the items of choice for centuries in India. In early Buddhist and Jain works, there is a mention about the sweets prepared from inspissated milk named as Sihakesara and Morandeka. It appears that the rich used to enjoy such delicacies at the end of their meals. Buddha allowed his followers to take some sweets for journeys on routes where it was difficult to get foodstuffs. In the Maurya period (75-300), the sweets were prepared from concentrated milk with the addition of honey, jaggery or sugar. In the post-Gupta period (AD 750 to 1200), milk was used in various forms. When half the quantity was evaporated, it was drunk. In case it was reduced to one third of the original quantity, it became a dish that was



appreciated. When one-sixth of the original quantity remained, it was used for preparing sweets and when only one-eighth remained, it was called 'Sarkara' (powder). The ancient medical literature clearly states that the physical and mental happiness of individuals depends on the food they take.

The art of preparing sweets from surplus milk was developed for commercial advantages by the halwais. Lack of cooling facilities to keep liquid milk fresh in warm climate led to the conversion of milk into indigenous milk products with comparatively longer shelf life. Although systematic survey for the amount of milk diverted for such conversions has not been carried out, according to a rough estimate khoa making units in India use about 7% of the total annual milk production (Rajorhia and Srinivasan 1979). Almost the entire activity of milk sweet production is currently dominated by the halwais, who use batch methods to cater to local demands.

Milk food delicacies are value-added products generating high profits. The demand for milk sweets is influenced by the nutritional and social values attached to each of them. (Reddy and Rajorhia, 1992)

Today the price of milk based sweets in the market is beyond the purchasing capacity of even the middle class people, with increasing emphasis and encouragement in greater utilisation of milk for fluid consumption. It is logical to presume that the quantity of milk diverted to these products would decrease resulting in further increase in the price of the sweets.

Manufactures of sweets from filled milk, which could be comparatively cheaper alternative for decreasing the cost of milk based sweets. The butter fat, thus recovered from milk would then be available for expanding fluid milk supply through reconstitution. In spite of increase in milk production to 74.4 million tonnes per annum, the per capita consumption is only about 214 grams. This is far short of the daily consumption of 270 grams.

The present research is an attempt to study the feasibility of using filled milk for the preparation of Khoa and Chhana and converting it into sweets namely Peda and Sandesh.

**The objectives are**

- 1. To develop suitable technology for the preparation of filled khoa and Chhana.**
- 2. To develop an appropriate technology for the preparation of filled Peda and Sandesh.**
- 3. To study the chemical quality of filled Khoa and Chhana.**
- 4. To study the chemical and organoleptic quality of filled Peda and filled Sandesh.**
- 5. To study the economics of the products prepared.**

# CHAPTER-II

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Review of Literature

# Review of literature

The literature on different aspects to the problems is categorized as follows.

## Filled Milk

Introduction	labelling
Definition	Nutritive aspects
Types of vegetable oil	Filled milk
Consumers acceptability	Filled milk products
Composition	Daries manufacturing filled milk

## Khoa

Introduction	Physico-chemical changes
Size of industry	Microbiology
Definition	Shelflife and packaging
Traditional approaches	Rheological properties
Classification	Economics of manufacture
Composition	Mechanised method
Factors affecting the quality	Various products from Khoa

## Chhana

Introduction	Microbiology
Size of the Industry	Shelflife and packaging
Definition	Nutritive value
Traditional approaches	Protein and packaging
Composition	Rheological properties
Factors affecting the quality	Economics of manufacture
Yield	New approaches to Chhana manufacture
	Various products from Chhana

## Peda

Introduction
Method of preparation
Shelflife and packaging
Chemical quality
Microbiological

## Sandesh

Introduction
Types of milk
Composition
Shelflife and packaging
Microbiological

# Filled Milk

## Introduction

Development of milk products with vegetable oils and fats offer advantages of low cholesterol content, low raw material prices, uniform quality without seasonal changes, high degree of security for supply, neutral taste and on shelf life. A particular vegetable fat is selected according to factors such as availability, price, and resistance to oxidation and also nutritional and physiological conditions.

## Definition

The term "Filled" according to **Hedrick (1969)** refers to those products in which part or all the milk fat is replaced by vegetable fat. According to **Fistere (1970)** the federal filled milk acts (21U.S. code, section 61 to 64) of U.S.A. In section 1, defines the term "Filled Milk" to mean any milk, cream, or skimmed milk, whether or not condensed, evaporated, concentrated, powered, dried or desiccated to which has been added, or which has been blended or compounded with any fat or oil other than milk fat, so that the resulting product is an imitation or resemblance of milk, cream, or skimmed milk, whether or not condensed, evaporated concentrated, powdered, dried or desiccated.

**Anon (1985)** reviewed the 1984 report of the UK Food Advisory Committee on the Skimmed Milk with Non-Milk Fat [filled milk] Regulations 1960. The regulations prohibit marketing of filled milks as dairy products; a schedule lists products specifically exempted from a requirement to warn against use for infant feeding. The recommendations of the Committee includes revocation of the labelling and advertising controls of the regulations, which have been superseded by the Food Labelling Regulations, but continuation of a specific label warning against use as a substitute for breast milk or infant formula; and a statutory requirement for nutritional equivalence between milk and filled milks. It is considered that amendment of the regulations should take place when separate controls are introduced for infant formulae, and that the 1960 Regulations should continue in the interim.

**Gupta et al (1987)** describes milk product substitutes including the following: margarine and dairy spreads, imitation cheese, tea and coffee whiteners, filled milk, imitation milk, protein concentrate beverages, soy yoghurt, infant foods and imitation

Ice-cream. The main advantage of these products is low cost, owing to the utilization of relatively cheap ingredients, such as vegetable protein and fat, emulsifiers and stabilizers. Dried milk and caseinates are also commonly utilized in these products.

### **Types of Vegetable Oils**

In relation to foods, the term fat and oil are almost interchangeable, chemically both consists of compounds known a triglycerides. In common usage fat is solid at room temperature whereas oil is liquid. The triglycerides in many animal products are solid at room temperature whereas from plant sources are liquid, so commonly the term animal fats contain higher concentration of saturated fatty acids than vegetables oils, so animal fats are considered saturated and hard and vegetable fats are called unsaturated. Most commercially processed vegetable oils are hydrogenated. This process changes unsaturated fatty acids into less saturated acids and therefore makes than harder. Thus in some respects hydrogenated vegetable oils are similar to animal fats.

**Kadan *et al* (1993)** reported that samples of dried filled milks (DFM) were made with several vegetable fats [almond oil, Trisun H95, Trisun HS-350, Trisun HS-500, peanut oil, cottonseed oil, coconut oil] and compared with [conventional] dried milk. [Fatty acid composition, flavour evaluation, O<sub>2</sub> in headspace and GC analysis indicated that] Trisun HS-500, hydrogenated cottonseed oil and hydrogenated coconut oil could impart stability to the DFM as high as that imparted by milk fat to conventional dried milk. Shelf life could be further enhanced by appropriate antioxidant [TBHQ] and storage conditions [24 degree C]. The simple technique of measuring O<sub>2</sub> consumption by the DFM was as effective as flavour evaluation, GC of volatiles or spectroscopy for screening large numbers of samples or as a quality control procedure.

According to **Brink (1968)**, Two type of filled milk is sold in U.S.A. One is combination of fluid skim milk, with or without added non fat dry milk solids, plus a vegetable fat, the second-type contains water non fat dry milk, a vegetable fat, with an additional source of protein such as soy protein or sodium caseinate.

**Webb and Whittier (1967)** reported that there is no close substitute for milk fat, as a result, products made from such substitutes differs in flavour, even though

their structural characteristic resembles the actual products.

**El-deeb *et al.*, (1984)** reported that hydrogenated oil could be used at 10% substitution in vanilla ices without noticeable effects on flavour, body or texture of the finished products.

**Blender (1970)** suggested use of partly hydrogenated soyabean and cottonseed oil containing lenoletic acid to lower the cholesterol level, but the flavour of the product were found to be poor.

**Blohorn (1978)** reported a fat similar to milk fat could be produced by transesterification of a mixture of 65% refined traditionated solid palm oil 30% refined coconut oil and 5% industrial tributyrin of food quality.

**Lampert (1974)** reported the use of partly hydrogenated soyabean oil and cottonseed oil in "filled milk" which resulted into poor flavour.

**Laustsen, (1986)** reported that there is two special vegetable fats were produced for use in dairy industry to provide alternative to butter fat. Polawar E 31 and Confao 5, both of which can be used in cheese and recombined milk products.

**Brick (1968)** mentioned the use of hydrogenated soybean, cottonseed oil or combination with corn or sunflower oil. However, it is difficult from technological aspect to formulate a product containing these later oils that are acceptable and thus of coconut oil based products remained most prevalent.

### **Consumers Acceptability**

**Russell & Sanderson (1971)** evaluated food products made from synthetic and filled milks for consumer acceptability in 2 test series. In one, 2 synthetic milks containing coconut oil and maize syrup solids, one having Soya protein and the other sodium caseinate, were compared with liquid whole milk for were liquid milk as a beverage, chocolate drink, white sauce, maize starch pudding, baked custard, muffins and plain cake. Whole milk was superior to both synthetic milks except in chocolate drink, muffins and cake. In chocolate drink, sodium caseinate milk was judged equal to liquid whole milk, but Soya protein milk was inferior. Milk containing sodium caseinate was the preferred synthetic milk. In series 2, the preferred synthetic milk and a filled milk were compared with liquid whole milk when used in the same products. The filled milk was liquid skim milk plus 3.5% coconut oil. Sodium caseinate milk was better than liquid whole milk for general palatability in plain

cakes. Liquid whole milk was significantly better than sodium caseinate milk but not than filled milk for general palatability in muffins. In other products, liquid whole milk received the highest rating, filled milk came second and sodium caseinate milk was least acceptable.

**Modler (1970)** formulated filled milks from fresh milk, vegetable oils and emulsifiers. The filled milks were pasteurized at 170 degree F for 8 sec, homogenized at 500-2500 lb/in<sup>2</sup> and cooled to 36 degree F. Studies on lipid oxidation and flavour score were made during storage at 40 degree F for 7 days. Soybean oil-filled milk prepared from lightly hydrogenated soybean oil, was quite acceptable when evaluated organoleptically at 24-h intervals of approximately 1 week. Thiobarbituric acid and peroxide values revealed that very slight oxidation had occurred during storage for approximately 1 week at 40 degree F. Monoglyceride emulsifiers with varying degrees of saturation were used to stabilize the emulsion of soybean oil in skim-milk. The more unsaturated monoglycerides tended to impart bitter flavours to the milk when used at a concentration of 0.1 degree (based on wt. of product) and also were less efficient emulsifiers when compared with saturated monoglycerides. Development of a very undesirable sulfide-like odour and flavour occurred under extremely high pasteurization temperature. The degree of off-flavour produced was directly proportional to time and temperature of heating

**Hedrick (1969)** stated that a consumer study on filled milk, marketed as imitation milk, was carried out in 1968 and 1969 in the Urbana-Champaign and Decatur, Illinois markets. Of an initial 100 households interviewed, 71% were aware of the product, 32% had tried it but only 8% were purchasing filled milk and only 18% could accurately describe the difference between filled and normal milk. Purchasers of filled milk were interviewed at the point of sale; 30% had been buying it since its introduction 6 months previously and per capita consumption was approximate equal to gal/wk. At least part of the sales appeared to be additional milk sales, 14% consuming more total milk products, including filled milk, than previously; 83%, however, indicated there was no change in the total amount purchased and 3% bought less, while 77, 68, 35 and 29% indicated that filled milk purchases replaced or partially replaced whole milk, 2% milk, skim-milk and dried skim-milk, respectively. In families buying filled milk, 65% of members drank it regularly, particularly children and teenagers, 23% occasionally and 11% never, while



corresponding values for fluid milk or skim-milk consumption were 27, 22 and 45%. Of 56 families regularly buying filled milk in June 1968, 73% were still buying it 7 months later, 30% buying only filled milk. Lower cost was given as the main reason for its purchase, although flavour and nutritional properties were also considered important.

Concern about the impact of diet on health has led consumers to reduce the consumption of foods perceived as being high in fat. **Bruhn *et al.* (1991)** studied the consumer attitude on fat substitute in dairy products by conducting mail survey of 2000 California household. Taste, safety and nutrition were most important in food selection. About 60% thought, foods containing Simplesse, (a fat substitute) would be healthier than traditional products. About half of the consumer were ready to try reducing fat products and willing to pay little extra for them.

### **Composition**

**Ashworth (1972)** estimated total Solids and protein in 715 samples of various dairy products, during 1968-1969 in NW USA. The means and ranges for protein % were as follows: 210 samples of whole milk, 3.41 (3.0-4.2); 121 samples of low fat milk, most of which will have been fortified with dried skim-milk, 3.78 (3.1-4.2); 115 samples of skim-milk, 3.52 (3.1-4.4); 45 samples of cultured buttermilk, 3.25 (2.8-3.6); 135 samples of Cottage cheese, 12.13 (10.6-15.2); 34 samples of sherbert, 1.12 (0.65-2.25); 11 samples of filled milk, 3.25 (2.65-3.77); 5 samples of imitation milk, 0.94 (0.85-1.06). Variation between brands and within brands during the year were studied for whole and low fat milk. The variation in protein content reduced the use that can be made of stressing protein in advertising, unless the protein content of products was standardized.

**Gregory & Hansen (1969)** reported that students of North Carolina state university used a complete randomized block design to evaluate the following beverage, each indicated highest, mean and lowest rated samples (3): (i) 3.25% fat homogenized milk, (ii) 3.25% modified vegetable-fat filled milk, (iii) 3.25% vegetable-fat non-dairy milk, (iv) low-fat (2%) milk (10% SNF), and (v) 3.25% polyunsaturated vegetable-fat filled milk. Skim milk was used to make all but (iii). Products (i) and (iv) which were equally acceptable, ranked higher than the other beverages.

**Horvath *et al* (1971)** sampled 8 brands of filled milk beverages (FMB) and 4 of liquid coffee whiteners at monthly intervals from retail markets in Arizona. Saturated fatty acids in the fat of FMB varied from 20 to 99%. Products with a high saturated fat content contained mainly lauric acid with smaller amounts of myristic, palmitic and stearic acids; those with high unsaturated fat content contained oleic acid with palmitic, stearic and linoleic acids also present. For FMB, variations in total fat content (3.23-3.51%) and its fatty acid composition were observed both between brands and from month to month. One coffee whitener had a saturated: unsaturated fatty acid ratio of 20: 80, whereas the other 3 brands contained mainly saturated fatty acids. Total fat content ranged from 7.85 to 11.55% and was more variable than in the FMB.

**Wang (1971)** did preliminary evaluation of slurry of 14 vegetable lipids system, two (A and B) were selected for manufacture of filled Cheddar and Romano cheese. After six months' ripening, flavour in the filled Cheddar cheese was typical, whereas filled Romano cheese was noticeably lacking. Gas-liquid chromatography revealed that the type of lipid had little effect on the free amino acid content of the cheese but influenced free fatty acid (FFA) formation. Low molecular weight FFA were in all cheeses. At six months, the filled Cheddar cheese contained about 90, 9, 88 and 18% of the amounts butyric, caproic, caprylic and capric acids in the control milk fat cheese. For Romano cheese with Lipid A, the corresponding FFA results were 55,18,35 and 4% for butyric, caproic, caprylic and capric acids, respectively. The formation of low molecular weight FFA in the filled cheese was not related to the fatty acid composition of the vegetable lipid.

### **Labelling**

**Weik (1969)** reported that products simulating milk or cream and made basically from water, vegetable oil and dried skim milk are filled milk products under the US Filled Milk Act; those containing no dairy ingredient are outside the Act and must be labelled imitation milk. Sodium caseinate is not considered to be a dairy product and must be described as sodium caseinate, milk derivative in a statement of ingredients. Other labelling requirements are (i) statement of product as e.g. Below Standard in Quality, Low in protein, where the level of ingredients is not nutritionally

equivalent to the dairy counterpart, (ii) margarine with half fat content for dietary purposes must be sold as imitation margarine because of the specific standard for margarine, (iii) addition of vegetable fat to cheese renders it a filled cheese and must be labelled additionally as Imitation-x-Cheese if it purports to resemble a specific variety, (iv) optional ingredients added to products having a mandatory standard e.g. Cottage cheese, cream cheese, must be declared e.g. Vegetable gum added or with chives, (v) sour cream made with acidification by lactic acid bacteria is subject to the standard for cream but with added ingredients must be described as sour cream dressing and (vi) acidified products made by addition of food acids with artificial flavours etc. must be described, as such e.g. acidified sour cream product. Some individual states enforce use of the word imitation on the labels of all substitute products.

## Nutritive Aspects

**Hedrick (1969)** considered filled milk and other filled dairy products nutritionally comparable to their dairy counter-parts if fat-soluble vitamins have been added and the fat and total solids contents are the same. Skim solids in filled milk from reconstituted skim milk powder might be considered slightly inferior. However, the content of protein, lactose, mineral and water-soluble vitamins and calories are identical in filled milk and regular cow milk.

**Breeding (1970)** stated that replacement of milk fat with a saturated vegetable fat, such as coconut oil that lacks significant amounts of linoleic acid, is not nutritionally acceptable for children or adults.

According to **Waite (1972)** the filled products made from coconut oil nutritionally contain less unsaturated long chain fatty acids and higher content of lauric acid, which raises level of blood serum of cholesterol. Soyabean oil has extremely high content of unsaturated fatty acids and low content of lauric acid.

## Filled Milk

**Henderson (1971)** has reported the following composition of "filled milk".

Ingredients	Qty.
1. Milk solid not fat from fluid skim milk or condensed milk.	8.5 to 9.0 %
2. Vegetable fat	3.5 %
3. Emulsifiers (Monoglycerides)	0.4 %
4. Stabilizers	0.02 to 0.3 %

The composition of filled milk given by **Miller (1968)** is as follows:

	Ingredient	Qty.
1.	Water	85.87 %
2.	M.S.N.F.	9.0 %
3.	Vegetable fat	5.0 to 6.0 %
4.	Stabilizer	0.2 %

**Cordon et al (1994)** studied the effect of stabilizers and emulsifiers on stability and sensory quality of vegetable oil filled milks. 4 formulation was selected in a preliminary study from a total of 31 different combinations, generated by combining 9 vegetable oils with different emulsifiers/stabilizers. These were HTST pasteurized and evaluated for stability and sensory quality during storage at 2 degree C. The 4 formulations (cottonseed oil with Actoloid D22 Type C stabilizer (mono- and diglycerides, sodium caseinate, carrageenan and sodium citrate); sunflower HB95 oil with Actoloid D22 Type A stabilizer (mono- and diglycerides, sodium caseinate, soy protein, carrageenan and sodium citrate); canola oil with emulsifier M (mono- and diglyceride flakes); and canola oil with Actoloid D22 Type B stabilizer (mono- and diglycerides, soy protein, whey protein, carrageenan, sodium citrate and disodium phosphate)) were stable during storage and it is suggested that any of the formulations could be used effectively for replacing coconut oil-based formulations. However, the formulation with sunflower HB 95 oil/stabilizer. A possessed the best sensory characteristics after 1 wk, whereas the formulation with canola oil/stabilizer B retained the best flavour and had least off-flavour after 3 wk of storage. Filled milk prepared using the latter formulation was similar in flavour quality to coconut oil-based filled milk.

**Ankrah (1971)** Twelve cartons each of Fan white and chocolate filled milks, from different production batches, were purchased and found to have the following mean composition (with range), respectively, (%): protein, 3.04 (2.63-3.41) and 3.22 (3.06-3.60); fat, 3.01 (2.24-3.46) and 1.55 (1.42-1.62); SNF, 8.92 (8.30-9.74) and 11.45 (9.91-12.66); and ash, 0.66 (0.48-0.76) and 0.67 (0.48-0.79). The proportion of daily protein requirements calculated to be met by drinking a carton of filled milk is tabulated for different age group and sexes, eg. 38% for a bov aged 1 yr, 51% for a 2-year old boy, 13% for a pregnant woman and 11% for a lactating woman.

**Medora (1971)** reported that less than 2% of the milk equivalent consumed in the Philippines is accounted for by local production, amounting to approximate equal to 9400 tons cows' and buffaloes' milk annually. There are approximate equals to 2000 dairy cows in the country and less than 2% of the 3.7 million Philippine carabaos (buffaloes) are milch animals, yielding 1-2 litres milk (10-12% fat) daily/head. Filled milk manufactured in the country from imported skim milk and locally produced coconut oil has a large share of the domestic market of products based wholly or partially on milk. In 1969, the sales volume of filled milk was 5500 000 cases; the most popular retail package is the 14- oz tin. The use of the term filled milk is discussed with reference to the FAO Code of Principles.

### **Filled Milk Products**

**Lautsen *et al* (1986)** gave recipes for 5 filled milk products made by using 2 Danish specialty vegetable fats.

**Pokrouskii *et al.*(1978)** prepared *Acidophilus* milk with complete replacement of milk fat by freshly prepared refined oil.

**Smith (1975)** reported that in Philippines filled and recombined, evaporated and condensed milk are made using 90% coconut oil and 10% maize oil.

**Bhandari (1976)** made flavoured filled milk using coconut oil and dried skim milk as the main ingredients. He found that Rose and pineapple were the most effective in making the coconut flavour of the filled milk.

**Jaiswal and Rao (1981)** prepared filled flavoured milk of acceptable quality.

**Thapar and Rao (1980)** reported acceptable quality in flavour, body and texture of vegetable fat filled Ice cream.

**Mandal and Rao (1978)** prepared acceptable good quality filled channa and filled rasogolla.

**Mathew and Rao (1981)** made acceptable quality of Ice cream using dalda vanaspati as substitute for milk fat.

**Jesudasan and Rao (1983)** reported that manufacture of Yoghurt from vegetable oil and skim milk is a feasible proposition.

**Cherian and Brave (1982)** reported acceptable quality of filled paneer by using dalda and groundnut separately.

**Broadway and Brave (1984)** prepared acceptable quality of Shrikhand from vegetable oil and skim milk. It did not differ significantly from buffalo milk product.

**Patel & Gupta (1983)** reported that refined, deodorized, hydrogenated vegetable fat (m.p. 36.3 degree C, I value 81.4) was heated at 120-125 degree C for 2-3 minutes with fresh skim milk, dahi, fresh cream (35% fat) or cultured cream, then filtered to remove most of the residue. The product made with 20% skim milk or 20% dahi lacked typical ghee flavour; inclusion of 10% fresh cream enhanced flavour production. Highest flavour scores (scale range from 9 for normal ghee to 1 for, untreated vegetable fat) were obtained using 10% dahi + 10% fresh cream (score 7.5), 10% cultured cream (7.4) or 20% cultured cream (7.6). Vegetable fat treated with 10% cultured cream and untreated fat respectively had peroxide values of 4.6 and 8.9 m-equiv./kg after 5 days and 11.4 and 20.3 m-equiv./kg after 15 days at 63 degree C. Table spread made from soybeans using untreated fat, treated fat and ghee respectively had flavour scores of 6.0, 6.6 and 7.0 and filled milk prepared from skim milk with corresponding fat sources scored 4.8, 5.5 and 6.3

**Foda *et al* (1976)** reconstituted skim milk was pasteurized at 145 degree F for 30 min, and then cream or maize oil was added to achieve 3% fat, and the mixture homogenized at 500 lb/in-2. Cheeses were made from both filled and control milks containing 7% or 10% NaCl. Pressed curd was pickled in its own whey in tins, with or without hot pepper. Cheese made from 7%-salted milk was stored at 8 degree C and that from 10% salted milk was stored at room temp. Samples were analysed after 0, 2, 4, 8 and 12 wk for moisture, titratable acidity, fat content, total and soluble N, NaCl content and total volatile fatty acids. A panel scored samples for appearance, colour, flavour, body and texture. Filled-milk cheeses had a higher moisture flavour due to maize oil also became less during ripening, and was masked by the addition of spices. Filled cheese had a higher salt, total and soluble N content, and less fat than the control; acidity increased during storage for both types, but was always higher in filled cheese. Total volatile fatty acids were less in filled cheeses throughout ripening.

**Filled Milk Cheese:** - A cheddar type cheese made from a mixture of skim milk and vegetable oil which is homogenized at 70 Kg/cm<sup>2</sup> was found to be satisfactory (**Peters, 1956**).

A blend of skim milk and corn oil, homogenized at  $100 \text{ kg/cm}^2$  was used to prepare Svecia and Post Salute type cheese. But the product had off flavour and weak body. (Lodin and Brelin, 1958)

A mixture of coconut oil, palm oil and rapeseed oil in the ratio of 40:50:10 with skim milk was found to yield acceptable quality Danish blue cheese (Nielson and Pihl, 1983).

Cheddar type cheese was manufactured from homogenized ( $35 \text{ Kg/cm}^2$  &  $55^\circ \text{C}$ ) mixture of equal volumes of cottonseed oil, soybean oil and reconstituted skim milk. The cheese obtained was ripened for 120 days, which developed defects such as foreign flavour and weak body (Rao-Jude and Rippen, 1967). Rao (1973) also prepared cheddar type and processed filled cheese using 'dalda vanaspati'.

A skim milk mixture containing added emulsifier, lecithin, citric acid and antioxidant was blended with polyunsaturated fat (safflower oil). The mixture was used for making cheddar type cheese successfully (Rhodes, 1966).

Mozzarella type filled cheese was developed in which the ratio of PUFA to saturated fatty acids was 1:4 or 1:1 with single homogenization at 500psi and addition of 0.02% calcium chloride (anon, 1970).

Ras cheese was made from concentrate of reconstituted skim milk (33% TS and 9% maize oil or soybean oil). It contained more moisture, less volatile fatty acids and more tyrosine and tryptophan than control cheese (El-Ghandour *et al.* 1983).

A special cheese from skim milk and edible oil with added enzyme was prepared. It was claimed to be enriched with amino acids, vitamins and kept well at  $4-10^\circ \text{C}$  for about 1 year (Entzmann, 1983).

Dietic cheese having high proportion of PUFA was made using mixed milk (cow, goat, ewe & buffalo) and vegetable oil (Sodiet, 1981).

Dutch, Brick, Pikantnyl and Roquefort type cheese were made from a fat emulsion consisting of 5% dried skim milk, 54.6% fresh skim milk, 0.3% sodium phosphate, 0.1% sodium citrate and 40% vegetable fat; homogenized at  $60^\circ \text{C}$  at  $5.0-7.5 \text{ MPa}$  after addition of 3 percent annatto. The cheese thus prepared showed good consistency and organoleptic quality. (Kozin *et al.*, 1975).

Soft cheese was manufactured from a mixture of reconstituted skim milk and soybean oil (3%) by standard process. It was reported that fresh cheese has oily and

bean like taste but the oily flavour decreased when stored for 1-2 months in whey (Hefnawy and Hafez 1987).

A Tilsit type of cheese was manufactured using skim milk and vegetable fat (Markes *et al.*, 1981). Foda *et al* (1976) used skim milk and maize oil to manufacture soft cheese of acceptable quality.

Kraft, introduced a Golden Image Imitation cheese Line" in the US. This range included Golden Image Imitation Cheddar and golden Image Imitation Colby as well as Golden Image Processed Cheese Slices and Processed Cheese food. The promotional material used in the launch pointed out that the butter fat had been replaced by maize oil, resulting in a reduction of the saturated fat content (John Me Carthy, (1990).

Abo-Elanga *et al* (1975) prepared filled Cheddar cheese and found that it contain more moisture but less fat then the control cheese.

Rao Jude (1965) and Rao Jude and Rippen (1967) manufactured Cheddar type cheese. The cheese product obtained was ripened for 120 days and scored for flavour, body and texture, while these cheeses were acceptable, they were found to develop defects such as foreign flavour and weak body.

Dib *et al* (1990) examined the effects of renneting temperature. [25,30, 31,32, 33, 34, 35, 36, 38, 40, 45 and 50 degree C] and treatment of the curd on factors such as coagulation time, curd tension, moisture content and compressibility of the cheese. The product, was then used as a standard with which to compare cheeses produced from filled milk. When emulsions of vegetable oil and reconstituted skim milk powder were substituted for liquid whole milk, the resultant filled cheese was of poor textural quality. Effects of adjusting renneting temperature, pH, and addition of calcium chloride on the quality of filled cheese were studied and a method for the production of filled cheese, of comparable quality to whole milk, soft, white cheese, was formulated.

Biernoth *et al* (1989) prepared a semi-hard to hard cheese product from a filled milk containing 1.2-40 wt% fat, containing preferably less than 30 wt.% saturated fatty acid residues. The flavour is said to be virtually indistinguishable from that of cheese made from natural milk.



Narimatsu *et al* (1985) prepared an unripened cheese-like food by normal cheese making techniques from filled milk or filled reconstituted milk, in which the added fat component is rape seed oil, or rape seed oil mixtures with other oils to give solid fat indexes of 20-55 at 10 degree C, 10-45 at 20 degree C, 025 at 30 degree C and 010 at 35 degree C in the mixtures. Such products were given much higher flavour scores than cheeses made from filled milk containing palm oil, coconut oil or tallow.

### **Dairies Manufacturing Filled Milk**

Smith (1977) outlined the operation of Dunkley & Pioneer Dairies Ltd. in Bermuda. The dairy produces about 35 products of which 21 are different types of ice cream. Most of the market milk is filled milk made from imported vegetable fat and dried skim-milk by recombination with water to give a fat content of about 3.2-3.3%, pasteurization, homogenization and packaging into cartons.

Schiess (1987) reported that in the Irish Republic there are at least 10 dairy concerns which produce 'imitation' or filled dried milk, butter or cheese (mixtures of milk and vegetable ingredients), and the country is the most important exporter of these products in the EEC. The main export is dried filled milk, much of which goes to the Canary Islands, or to the UK and USA in bulk for food use and as branded products. Within Ireland itself, imitation butters have shown a rapid expansion to about 20% of the market for spreadable fats; annual production of these mixtures is about 10 000 t, 80% for the home market. This has had a drastic effect on butter consumption, which decreased by 40% between 1984 and 1986: a decrease of 15 000 t milk fat, of which only 3000-4000 t was made up by use of imitation products. The butter manufacturers have responded by an advertising campaign emphasizing the 'naturalness' of butter and 5 companies have produced spreadable butters. The Irish Industrial Development Authority has been supporting export expansion for imitation butters.

# KHOA

## Introduction

Traditional milk products play a significant role in the economic, social, religious and nutritional functions of the Indian masses. Indian dairy plants, looking for value addition and higher profitability, have expressed interest in mass production of indigenous milk products. Emphasis was laid upon the characterization of sensory, rheological and physio/chemical properties and use of least expensive packaging materials for extending the shelf life of traditional milk products.

Khoa, an important Indian milk product, is prepared by continuous boiling of milk until desired concentration of solids (65 to 72% TS) and texture is achieved. Buffalo milk is preferred to cow milk in making Khoa because besides giving a larger turnout, it gives a product of soft body and smooth texture which is highly desirable for Khoa-based sweets. Khoa is manufactured primarily by halwais in jacketed kettles, which inherently suffer from several disadvantages as given below:

- Wide variation in chemical, microbial and sensory qualities from batch to batch.
- Small-scale batch process unsuitable for commercial adoption.
- Low heat transfer coefficients causing equipment to be bulky.
- Insanitary operation as it is open to atmosphere.
- Excessive strain and fatigue on the operator.
- Poor packaging.
- Limited shelf life of the product.

## Size of Industry

In the unorganized sector of dairy industry, khoa manufacture is a major activity. Khoa is an intermediate product and forms base for a large number of sweets such as burfi, peda, milk cake, kalakand, gulabjamun etc. It is a milk product obtained by rapidly evaporating milk in shallow pans to a sticky mass, which can be preserved for several days. Some 9 lakh tonnes of khoa valued at Rs.4,500 crores is produced in the country.

## Definition

Khoa refers to the partially dehydrated whole milk products prepared by the continuous heating of milk in a karahi over a direct fire, while also constantly stirring

cum scraping by using a khunti till it reaches a semi- solid (doughy) consistency.

According to the **P.F.A. rules (1976)**, Khoa is the product obtained from cow or buffalo or goat or sheep milk, or a combination thereof, by rapid drying. The milk fat content should not be less than 20 % of the finished product.

Khoa is a product obtained from cow, buffalo or mixed milk by heat dessication of milk to 65-70% solids in an open pan. Khoa, also called Khawa or Mawa, is use as a base material for a variety of Indian sweets.

### **Traditional Approaches**

Typically buffalo milk in 4-6 liters lots is simmered with vigorous scraping in a shallow pan over direct fire till a semi-solid mass is formed. Considerable amount of free fat is released towards finishing stage, and mass turns relatively non-sticky on the heating surface. Each lot takes 5-10 minutes to finish. Product made from buffalo milk is whiter while that made from cow milk yellowish; both with slight tinch of brown. In the commerce, three grades of khoa are known.

### **Classification**

#### **Pindi**

It is characterised as a circular ball of hemispherical pat with smooth and homogeneous body and texture. This possesses characteristic cook flavour and is preferred for the preparation of burfi and peda.

#### **Danedar**

Granular texture and uneven body characterize this form of khoa. Usually, 0.1 percent of citric acid (on product basis) is added during the heat desiccation process in shallow pan to obtain such texture. This forms base for the preparation of kalakand (granular burfi), milk cake and granular milk sweets.

#### **Dhap (Kaccha mawa)**

It is characterized by loose sticky body and smooth texture which is attributed to higher moisture content and less intensive heat treatment. It is preferred for the preparation of gulabjamun as it permits formation of uniform balls suitable for frying and absorption of sugar syrup.

### **Composition**

Khoa is a product obtained from cow, buffalo or mixed milk by heat desiccation of milk to 65-70% solids in an open pan. Khoa, also called Khawa or

Mawa is used as a base material for a variety of Indian sweets.

**Khoa has the following composition:**

	<b>Cow</b>	<b>Buffalo</b>
<b>Moisture %</b>	25.6	19.2
<b>Fat %</b>	25.7	37.1
<b>Protein %</b>	19.2	17.8
<b>Lactose %</b>	25.5	22.1
<b>Ash %</b>	3.8	3.6
<b>Iron (P.P.M)</b>	103	101

Khoa is expected to contain a minimum of 20% milk fat to meet the legal requirements in India. The Bureau of Indian Standards has laid down the following specification of khoa.

Moisture % by weight, (Max.) 28.0

Fat % by weight (On dry basis), (Min.) 26.0

#### **Laboratory Samples**

**Bhat et. al. (1949)** studied the chemical composition of Mawa and gave the averages of the constituents as 19.69% Moisture, 26.38% Protein, 29.72% Fat, 20.24% Lactose, 3.67% Ash, 1.45% Calcium, 0.65% Phosphorous and traces of Iron content.

**Boghra & Mathur (1996)** analyzed the sample taken at various stages of khoa preparation from buffalo and cow milk. It showed gradual and marked decrease in moisture content (approx. 33%) between milk and coagulation stage, about 15% at intermediate (I and II) and about 4 to 55 between simulating dhap and final khoa from both species. This resulted in simultaneous 4 to 6 folds increase in protein, fats, lactose and milk salts. The ratio of concentration for major constituents was higher at all stages while converting cow milk into khoa. A concomitant increase of about 3.5 to 6 and 3.5 to 7 times in total mineral upto khoa observed from buffalo and cow milk respectively. Marked increase in soluble minerals from milk to coagulation stage took place. Soluble calcium, phosphorous, magnesium and zinc attained the highest levels at this stage and showed marked reduction thereafter upto khoa stage. Soluble citrate,

sodium, potassium, chloride, copper and iron increased gradually and reached to maximum levels at khoa stage.

**Sharma & Lal (1999)** studied the effects of khoa preparation and storage of khoa under a light source on water-soluble vitamins content. Water-soluble vitamins content of khoa may be significantly lower than that of the milk from which it is prepared, due to heat processing / methods used in khoa production and storage of the product in illuminated display cabinets. Results were compared with values obtained for starter milk. Khoa was prepared using a conventional method and stored in an aluminum tray at room temperature. (18-25 degree C) for 24 h in a chamber fitted with a fluorescent light tube (2440 lumens) at a height of 1 m above the tray. Conversion of milk into khoa caused considerable losses of water-soluble vitamins. These losses were 23.61, 14.46, 21.28, 33.06 and 32.15% for thiamin, riboflavin, vitamin B6, folic acid and vitamin C, respectively. During subsequent storage of khoa, a general decrease in water-soluble vitamins was observed. Losses in vitamin B2 and vitamin C in khoa stored under light were 16.35 and 8.16%, respectively; corresponding values for khoa stored under darkness were 1.37 and 4.28%. Other vitamins were not affected by storage of khoa under light.

**Ranganadham & Rajorhia (1989)** prepared khoa from cows' milk (3-5% fat) or buffaloes' milk (4-6% fat). Free-fat content of khoa increased with increase in milk fat level, irrespective of type of milk used. Free-fat content of buffaloes' milk khoa was higher than that of cows' milks khoa at all fat levels. Homogenization of milk reduced the free-fat content of khoa by approx. 50%. Free-fat content increased with increased TS in khoa. Addition of Tween-80, glycerol monostearate and sodium citrate separately (0.1% by wt. of milk) prior to khoa manufacture reduced the free fat in khoa by about 9-14%.

**Sapre & Deodhar (1989)** determined the biological activity of vitamin A in buffaloes' milk and khoa by feeding vitamin A-deficient rats a vitamin A-free diet supplemented with 25 IU synthetic vitamin A (SVA) or with milk or khoa containing 25 IU vitamin A. During the 30-day supplementation period, the extent of improvement in growth rate, liver weight, and levels of vitamin A in liver and blood serum were taken as an indicator of biological activity. Results indicated vitamin A from the 3 sources was in the order milk greater than khoa greater than SVA.

**Srinivasan & Kumar (1982)** prepared three type of khoa from three different type of milk. They observed that the mean composition of cows' milk khoa, buffaloes' milk khoa and fresh market khoa (3 samples of each) was: moisture, 30.9, 22.3 and 28.4%; fat, 22.0, 32.2 and 24.6%; protein, 19.1, 17.7 and 19.0%; ash, 3.7, 3.7 and 3.6%; lactose, 24.2, 23.7 and 25.2%; titratable acidity (% lactic acid), 0.52, 0.35 and 0.50; peroxide value (m-equiv./kg fat), 0.05, 0.06 and 0.08; and free fatty acids (% oleic acid), 0.03, 0.08 and 0.05. All 3 types of khoa conformed to standards laid down by the Prevention of Food Adulteration Act (1954) and the Indian Standards Institution.

**Goyal & Srinivasan (1992)** studied the humidity-moisture sorption relationship of khoa. The sorption isotherms for the three types of khoa samples (from cow's milk, buffalo's milk and market) were observed to be of typical sigmoid type and showed steep rise above 45% R.H. The desorption occurred in all the three types of khoa samples under all the relative humidities ranging from 11 to 92%. The equilibrium moisture contents of less than 17, 12 and 21% respectively. In case of khoa from cow's milk, buffalo's milk and market corresponding to about 54% R.H were observed to be safe moisture content from the consideration of avoiding the mould growth, but at these moisture levels, the khoa samples were hard. Above 55% R.H., the samples of khoa developed mould growth.

### **Market Samples**

**Boghra & Mathur (1991)** analysed forty samples of khoa from 5 different shops of Karnal City for minerals. A noticeable difference in magnesium, phosphorus and zinc content between samples, and a significant variation for calcium among shops, was observed. The market samples of khoa contained (mg/100 g) calcium 654.00, magnesium 66.67, phosphorus 376.55, citrate 517.36, sodium 182.88, potassium 368.00, chloride 331.65, copper 0.16, iron 2.43, and zinc 2.43.

**Ghatak & Bandyopadhyay (1989)** obtained khoa samples (57) from retail sweet dealers in Calcutta between June and Dec. 1986. They found that the samples were mainly of good texture and organoleptic quality (3 had a flat and, 2, a rancid flavour). Chemical composition was as follows (mean values in parentheses): moisture 23.8-32.7% (26.3); fat, 17.6-27.3% (24.3); protein, 21.6-23.3% (22.8);

lactose, 19.4-21.2% (20.8); ash, 3.57-3.85% (3.71); titratable acidity, 0.23-0.78% (0.58); and peroxide value 0.06-0.18 (0.13). The iodine test was positive for 5 samples, indicating that they were contaminated with starch.

Narain & Singh (1981) collected market khoa samples from 3 districts of Varanasi City collected monthly from Nov. 1975 to Feb. 1976 and they were compared with control samples prepared in the laboratory from cows' milk (5.1% fat), buffaloes' milk (6.7% fat), or a 50:50 mixture thereof. Physical properties examined were general appearance, body and texture, flavour, suitability for sweet making and starch content. Market khoa samples contained significantly higher moisture contents ( $P$  less than 0.01) and protein contents ( $P$  less than 0.05) than control samples. Fat content of market khoa was significantly lower ( $P$  less than 0.05) than that of buffaloes' milk khoa, but did not differ significantly from the other control samples. Lactose content of market khoa was significantly lower and Fe content significantly higher ( $P$  less than 0.01) than that of cows' milk or mixed milk khoa. Ash, Ca and P contents did not differ between market and control samples of khoa. Many market khoa samples did not conform to Indian Standards Institution specifications with respect to moisture and fat contents.

## **Factors Affecting the Quality**

### **a. Type of Milk**

Buffalo milk in India finds preferential uses in the manufacture of heat concentrated milk products like Khoa, Rabri, Kheer and Basundi in which the open pan technology of condensing is employed. Buffalo milk always results in higher yields and superior quality condensed products as compared to cow milk products. Four litres of buffalo milk gives one kg of Khoa, whereas five litres of cow milk will be required to get the same quantity. The heat-induced changes during manufacture of Khoa include complete denaturation of whey proteins, breakdown and interaction of casein to form new components, increased reducing capacity to resist oxidation and development of characteristic cooked flavour. Khoa from buffalo milk is softer and smoother than the one obtained from cow milk. Buffalo milk Khoa produces milk sweets with soft texture, because of the presence of proportionately higher amounts of fat. The standard of Khoa prescribed under the Prevention of Food Adulteration Rules in India is heavily slanted on the use of buffalo milk. Cow milk with low fat content

especially that drawn from crossbred animals would result in Khoa with lower than 20% fat, inviting punitive action. Technology was developed to produce Khoa using different sources of milk ingredients such as vacuum concentrated milk, SMP and cream and from milk concentrated by reverse osmosis. The quality of Khoa is better when made from buffalo milk as Khoa from cow milk is inferior due to its moist surface, sticky and sandy texture, which is not considered suitable for the preparation of sweetmeats (De and Ray, 1953). The higher emulsifying capacity of buffalo milk fat due to the presence of larger proportion of butyric acid containing triglycerides (50%) compared to only 37% in cow milk fat may be responsible for smooth and mellow texture of its Khoa (Sindhu, 1996).

### **Buffalo Milk**

Sapre & Deodhar (1991) evaluated the nutritional quality of milk proteins at different stages during the preparation of khoa from buffaloes' milk. Khoa was prepared by heating buffaloes' milk (5% fat) with steam (100-105 degree C) at 1406 kg/cm pressure. Samples were analysed for moisture, fat, protein, lactose and lysine content at initial, intermediate (dhap) and final stages of khoa preparation. The decrease in moisture content from 87.9 plus/minus 0.31 (milk) to 35.6 plus/minus 0.63% (khoa) was associated with increased protein (from 4.1 plus/minus 0.12 to 19.8 plus/minus 0.12%), fat (from 5.0 plus/minus 0.01% to 22.3 plus/minus 0.12%) and lactose (from 4.4 plus/minus 0.05 to 21.0 plus/minus 0.24%) contents in milk and khoa, respectively. Lysine content was similar in milk and khoa. In rats the NPU and net protein ratio of dhap and khoa were significantly higher than those of the initial milk. Results suggest that the nutritional value of milk proteins does not decrease during khoa preparation.

### **Dried milk**

Boghra & Rajorhia (1983) examined the use of sources of milk solids, other than fluid milk (e.g. dried milk) in the manufacture of khoa. Sensory and chemical properties of khoa produced from dried milk were influenced by the type of milk (cow or buffalo), method of drying (roller- or spray drying) and level of reconstitution (15, 31, 40 or 65% TS). Roller-dried milk reconstituted at 40% TS gave a product comparable to traditional khoa. Spray-dried milk reconstituted at greater than 31% TS yielded a product that was sticky and lacked typical cooked flavour; an acceptable



product was obtained when spray-dried milk was reconstituted at less than 31% TS. Final heating of reconstituted milks in an open pan was necessary to reduce moisture content, improve texture and develop the characteristic cooked flavour.

### **Sweet Cream Buttermilk**

Chaudhari *et al.*, (1992) determined the effects of 5 levels (0, 25, 50, 75 and 100%) of substitution of buffalo milk by sweet cream buttermilk (SCBM), both with and without homogenization, on yield, physicochemical characteristics, Instron texture profile and sensory properties of khoa. Fat level in all milk blends was adjusted to 6%. Khoa yield decreased ( $P<0.05$ ) with increasing level of substitution and homogenization increased ( $P<0.05$ ) the yield at each substitution level. With increasing level of substitution, significant decreases ( $P<0.05$ ) were noted in moisture, lactose, titratable acidity, colour reflectance value, brittleness, cohesiveness, springiness, gumminess and chewiness, and increases ( $P<0.05$ ) in fat-in-DM, protein, ash and free fat. Compared with corresponding samples made with non-homogenized blends, homogenization increased moisture content and reflectance value but decreased fat, fat-in-DM, ash and free fat, and gave a product that was softer, less springy and chewy, more cohesive and gummy, and of superior body/texture and colour/appearance. Results showed that substitution with SCBM to levels of 25% resulted in khoa of satisfactory quality at reduced raw material costs and that homogenization of the milk blend was advantageous.

Although satisfactory quality khoa was obtained from roller dried whole milk, the spray powders reconstituted to 65% total solids yielded the product which lacked the characteristic nutty flavour. Reconstitution of whole milk powder to less than 40% total solids was necessary to prolong the heating time for unmasking the sulphhydryl groups so as to increase the intensity of cooked flavour and to release the free fat to avoid stickiness.

### **Sour milk**

Rajorhia *et al* (1990) studied the effect of milk quality on the chemical, sensory and rheological properties of Khoa. They observed that Khoa from slightly soured milk (0.2% lactic acid) did not have much adverse effect on the flavour of Khoa while Khoa prepared from excessively soured milk had a salty taste, however the coarse texture of Khoa increased with increase in the acidity of milk. Increase in size and hardness of the grain lead to poor body and texture of Khoa.

Smoothness of Khoa was also adversely affected by the developed acidity. The hardness of Khoa was observed to have increased from 19.47 mN to 22.85 mN and 28.44 mN due to increase in the acidity up to 0.19% and 0.27% lactic acid, respectively. Gumminess and chewiness of Khoa was also increased due to the developed acidity in milk and was reduced by neutralization of the same.

The main reaction in the manufacturing of Khoa is the heat denaturation and coagulation of milk proteins particularly the serum proteins and their interactions with casein and other constituents. This process is accelerated by the incorporation of air and frothing during the stirring. In spite of a very high concentration of lactose it does not crystallize out due to high viscosity of the product as a result of higher solids and coagulation of proteins.

#### **b. Fat percentage**

A minimum of fat level of 4 percent in cow milk and 5.5 percent in buffalo milk is essential for production of suitable body and texture in Khoa and to make it acceptable for use in sweet making.

#### **c. Condition of Dehydration**

Jadhav *et al.*, (1990) prepared Khoa by dehydration of heat induced foam using the milk in the proportion of 1/2, 1/11, 1/10, 1/9, 1/7 and 1/6<sup>th</sup> to the capacity of Karahi. The product was also prepared by traditional method with same quantity of milk used in each treatment of foam dehydration method. The time required for the preparation of khoa was less upto 1/10<sup>th</sup> of foam treatments than corresponding treatments of conventional method. The khoa prepared from 1/12<sup>th</sup> and 1/11<sup>th</sup> treatments of above method was of excellent quality in respect to taste, colour and physical make up followed by 1/10<sup>th</sup> and 1/9<sup>th</sup> treatments, which were also liked very much and found superior over the treatments of conventional method. The chemical composition of khoa prepared by both the methods was almost similar, indicating that all the constituents are evenly distributed in khoa prepared by foam dehydration method.

#### **Physico-Chemical Changes**

The various physico-chemical and biochemical changes occur during the manufacture and storage of khoa. The investigation extends to basic chemistry of protein to correlate denaturation, lactose, fat minerals and vitamins as influenced by

progressive concentration during manufacture and subsequent storage of khoa. There are effects of the quality of milk, and acidity and neutralization as prevalent in the field conditions on the sensory, chemical and rheological properties of khoa.

Several heat-induced changes take place during the desiccation of milk. Whey proteins are almost fully denatured. Casein are also irreversible denatured from colloidal state to non-dispersal state. Almost half of the globular fat is released as free fat-the extent of which depends upon the type and fat content of milk, and the manufacturing process. Usually, 44.8 to 62.8 percent of fat appears as free fat in khoa (Ranganadham and Rajorhia, 1989). Lactose is present in form of a super-saturated solution dispersed in form of fine droplets. Absence of sensorily perceived coarseness due to lactose crystals is noteworthy in this product (Garg *et al.*, 1989).

Ghatak and Bandyopadhyay (1989) investigated chemical quality of khoa marketed in Calcutta. The total reducing capacity increases typically from 2.3 mg (as cystein HCl/gm of milk solids) to 19.5, while re-dox potential increases from 0.20 to 0.35, pH decreases from 6.60 to 6.35, soluble nitrogen, free fatty acids and peroxide values increase with concomitants loss of lactose. The sorption isotherms for khoa are of typical sigmoid type and show a steep rise above 45 percent RH. Desorption occurred under the range of 11 to 92 percent RH. Above 55 percent RH, khoa samples tend to develop mould (Goyal and Srinivasan, 1989). The Shelf life of khoa about 2-4 days under ambient conditions and 3 weeks under refrigerated conditions. Khoa made by adapting the roller drying process displayed a shelf life of less than 5 days at 30° C, and 15 days under refrigerated storage.

### **Laboratory Samples**

Gothwal & Bhavadasan (1992) prepared khoa from buffaloes' and cows' milks and evaluated for browning, as were samples of sterilized milk (with and without added cane sugar), condensed milk and skim milk powder. Khoa prepared from buffaloes' milk had higher levels of TS and browning than that prepared from cows' milk; commercial samples were more susceptible to browning than laboratory samples, possibly due to use of neutralizing agents in market khoa. Effects of storage at 5-30 degree C on browning of khoa were also determined, and, at all temperature browning increased more in cows' milk than buffaloes' milk khoa; lower temperature storage prolonged shelf-life in terms of browning, 5 degree C storage resulting in

negligible changes in colour. Effects of storage temperature (20-35 degree C) on browning in condensed milk were also studied; storage at 20-25 degree C resulted in very little browning, whereas storage at 35 degree C for 8 months produced about 5x as much. Changes in viscosity of this condensed milk followed a similar trend. Effect of storage temp. (20-35 degree C) on browning index and available lysine levels in skim milk powder was also examined. Increased storage temperature caused increased browning indices after 7 months; further storage at 20 and 25 degree C caused little change in colour, but storage at 30 and 35 degree C caused a progressive increase. Losses in available lysine tended to increase with duration and temp. of storage. Storage of sterilized milk at room temp. for up to 180 days resulted in a small increase in browning intensity, more so in samples containing cane sugar. After 5 months, the increase in browning intensity was somewhat lower, as a % of initial values, in buffaloes' than cows' milk.

Sawhney *et. al.*, (1997) determined the influence of water activity adjustment in khoa was evaluated in relation to sorption characteristics, product acceptability and microbial stability, Isotherm parameters using G.A.B. equation. The monolayer moisture content increased from 3.292 g water/100 g solids for unblended khoa of 0.96 aw) to 9.1561 g water/100 g solids for khoa-blend adjusted to 0.866 aW) using 15% sucrose, 4% glycerol and 2% starch. The parameters of texture profile analysis, viz., cohesiveness, springiness, gumminess and chewiness of the above khoa-blend decreased during storage as compared to other khoa-blends and was found organoleptically acceptable even on the 8th day of unrefrigerated storage. The microbial growth rate constants for total bacterial counts, yeast and mould counts and spore counts decreased with decrease in water activity.

## **Microbiology of Khoa**

### **Market Samples**

Sharma *et. al.*, (1972) studied the bacteriological quality of Khoa sold in Udaipur city. A total of 220 samples of Khoa was collected from halwais and examined for the Standard Plate. Coliform and enterococcus counts. Fairly wide variations in the counts of individual samples of market Khoa were observed, the averages of the three counts being 950,000, 8,700 and 80,000/g, respectively.

Fifty-five samples of raw milk used for preparing Khoa were found to contain relatively much higher counts of all groups of organism.

**Naidu, & Ranganathan (1965)** studied the microbiological quality of market khoa as well as its deterioration on storage at room temperature. 35 samples of khoa collected from different 'Halwais' in Karnal were examined for presence of starch and sugar, moisture content, organoleptic and microbiological quality. They observed that there was no significant correlation between organoleptic quality of market khoa and the total count, since the majority of the samples considered good organoleptically had high counts. The spore count, however, was found to be slightly higher as compared to thermophiles. Yeast and moulds were generally found in small numbers. The keeping quality of khoa was studied by storing samples for varying periods at room temperature (30° - 1° C). It was observed that the product rapidly deteriorated depending upon the period of storage. Mouldy growth was clearly noticeable on the surface and sides of samples stored for 72 hours.

**Ahmad & Ranganathan (1967)** studied the microbial deterioration of Khoa in relation to degradation of constituents. *B. subtilis* and *Micrococcus* species were inoculated into khoa samples, incubated at 22°C and 37°C. Changes in organoleptic quality and breakdown of lactose, fat and protein were observed. It was found that visible signs of deterioration as well as marked breakdown of the constituents occurred much earlier in the samples incubated at 37° C than those at 22° C. *B. Subtilis* caused marked breakdown of protein while the *Micrococcus* species poor proteolytic activity.

**Kumar & Sinha (1989)** carried out the study on the incidence of coliform bacteria ('total' and 'faecal') in paneer, gulabjamun and khoa (31, 19 and 20 samples, respectively.) obtained from the experimental dairy of the National Dairy Research Institute (Karnal, India), and from local markets in India. 84, 74 and 67% of paneer, gulabjamun and khoa, samples respectively, showed unsatisfactory levels of coliforms. Values for total and faecal coliforms were (/g): paneer, 7.3 to greater than 10 000 and 0 to greater than 10 000; gulabjamun, 0-120 and 0-100; and khoa, 0-980 and 0-750, respectively.

## Laboratory Samples

**Sohal et. al., (1993)** investigated the survival of *Escherichia coli* and *Staphylococcus aureus* during production of khoa. Heat processing of milk containing from 3.6 to 6.5% fat at either 63 or 73 degree C eliminated all *E. coli*. Under similar processing conditions, *S. aureus* was recovered, but only when heated in milk at 63 degree C containing 7.5% fat. Potassium sorbate (3000 p.p.m.) appeared more effective in inhibiting growth of selected yeast and fungi in khoa at 7 degree C compared to ascorbic acid (3000 p.p.m.). Reducing aw of khoa from 0.97 to 0.93 did not appear to enhance the preservative effect. Reduction of *E. coli* or *S. aureus* in khoa during prolonged storage at 6-7 degree C was less than 1 log cycle, regardless of aw or preservative type. Survival of *S. aureus* in khoa appeared to be enhanced with a decrease in aw. The potential for pathogens to survive in khoa during processing should be taken into consideration when formulating heating protocols.

**Varadaraj & Nambudripad (1986)** studied the growth of *S. aureus* inoculated into khoa prepared with 3 levels of moisture (26-28, 38-42 and 45-48%) and stored at room temperature (25-35 degree C) or under refrigeration (4-5 degree C) for 2 days. Strains of *S. aureus* inoculated at  $1 \times 10^3$  colony forming units (CFU)/g of khoa, grew well reaching 10-1-2 CFU/g in 48 h at room temperature, but failed to grow in khoa under refrigeration. Moisture levels did not show any significant effect on staphylococcal growth. Microtome section of khoa revealed the occurrence of staphylococcal clusters, which gradually increased in size as the storage period, progressed from 24 to 72 h ultimately resulting in large clumps of cells. Strains of *S. aureus* grown in brain heart infusion and nutrient broths enriched with autoclaved solutions of casein and lactose showed extensive staphylococcal growth in comparison with control broth. The presence of casein and lactose in khoa, plus its loose texture, make it an ideal growth medium for *S. aureus* and a potential health hazard as a result.

**Kumar & Srinivasan (1984)** reported that samples of cows' milk khoa, buffaloes milk khoa and commercial khoa, respectively, had the following mean microbial counts/g: standard plate count 4400, 5800 and 17 000; acid-producers, 2200, 3200 and 2500; proteolytic organisms, 1500, 2200 and 2500; chromogenic organisms, 1200, 1500 and 2400; lipolytic organisms, 250, 540 and 430; aerobic

sporeformers, 71, 77 and 31; and yeasts/moulds, 7.5, 10 and 38.

**Ghodeker & Dudani (1982)** inoculated 2 pathogenic strains of *Staphylococcus aureus* and 4 of *Escherichia coli* (about 10-4/g) into khoa samples that had been prepared aseptically; uninoculated samples served as controls. During incubation at 37 degree C, the pathogenic count rapidly increased to about 10-9/g on day 2, remained at 10-8-10-9/g until about day 7, then gradually declined, but pathogens were still present at 10-3-10-4/g (*E. coli*) and 10-6/g (*S. aureus*) on day 22.

**Patel et al, (1981)** Milk obtained from buffaloes given aflatoxins contained aflatoxin ml at 2.7-6.0 ng/ml. Khoa produced by directly heating the milk for 3-4 h (186-225 g khoa per 1 milk) contained aflatoxin ml at 10.2-26.8 ng/g. Of the aflatoxin in milk, 83.0-98.5% was recovered in khoa, indicating that aflatoxin ml is resistant to severe heat treatment. Microbiological quality of khoa varied considerably, SPC counts from 3.2 to 332.7 x 10<sup>3</sup> cfu/g. Among these 3.2 to 3.0 x 10<sup>3</sup> cfu/g are acid formers, 2.5 to 21.3 x 10<sup>3</sup> cfu/g proteolytic type, 2.1 to 31.5 x 10<sup>3</sup> cfu/g chromogenic type and 200/g of sporeformers. It is paradoxical that so intensely heat-treated product should have such high microbial counts and consequently so little shelf life, all of, which is attributable to post, manufacture handling of the product.

### **Shelf-life and Packaging**

Khoa has a limited shelf life of about 5 days at 30° C. In the absence of proper packaging, the egress of moisture from the product adversely influences the texture and enhances the rate of chemical deterioration such as oxidation and browning. Different workers have studied the effects of different packaging materials and the preservatives on the shelf life of Khoa. Using four-ply laminated pouches and tin container, it was possible to increase the shelf life of Khoa upto 13 days at 30° C and to 75 days in the cold storage. Sterilization of polypacks with gamma radiation using CO<sup>2</sup> prior to product filling proved to be beneficial. Addition of 0.3% potassium sorbate at the last stage of Khoa-making increased its shelf life by another 10 days. Vacuum packaging of Khoa could enhance the shelf life up to 120 days in refrigerated storage (**Rajorhia et al, 1984**). The effect of metals on the shelf life of Khoa was studied by **Jalil et al (1963)**. These workers observed that Khoa prepared in iron pan has minimum shelf life, while that prepared in stainless steel pan has maximum shelf life. They suggested that the absolute shelf life of Khoa could be enhanced to 15-20

days by eliminating the contamination with chelating metals.

**Boghra (1988)** observed that addition of iron (1.25, 2.5 and 5%) and copper (1.0, 1.25 and 1.5%) enhanced the lipolytic and oxidative deterioration of Khoa during the storage at  $<10^{\circ}\text{C}$  for 14 days as was clear from the increase in free fatty acid and peroxide content. Iron had more pronounced effect than copper. Soluble proportion of naturally occurring iron and copper in the Khoa had a positive correlation with the development of rancidity in it. Concentration of soluble calcium, magnesium, phosphorous and citrate had a positive correlation with its hardness.

**Reddy & Khan (1993)** studied the effectiveness of antimicrobial agents Nisaplin (commercial nisin) and potassium sorbate and commonly available packaging materials (aluminium foil, polyethylene and parchment paper) on microbial quality of khoa during storage at 37 and  $5^{\circ}\text{C}$ . Results showed that counts of mesophilic aerobes, yeasts and moulds in khoa were reduced by the incorporation of 0.3% potassium sorbate (product wt basis) and on packing in aluminium foil.

**Kumar & Srinivasan (1983)** studied the effects of 3 different flexible packaging materials viz. Poster paper/A1 foil/low density polyethylene (LDPE) (55/60 gsm, 0.02 mm and 150 gauge)-P<sub>1</sub>, poster paper/A1 foil/LDPE (55/60 gsm, 0.009 mm and 150 gauge)-P<sub>2</sub>, MST cellulose film/LDPE (300 and 150 gauge)-P<sub>3</sub>, and also tin cans-P<sub>4</sub>, on the microbiological quality of three types of khoa samples. i.e. prepared in the laboratory from cow's milk, buffalo milk and purchase from market, when stored at  $37\pm 0.5^{\circ}\text{C}$  & 60% RH for various time intervals. The 3 types of khoa samples packaged in P<sub>4</sub> showed minimum growth of each type of microorganism followed by the samples packaged in P<sub>1</sub>, P<sub>2</sub> and P<sub>3</sub> in ascending order. The types of khoa, intervals x types of khoa all individually significantly ( $P<0.01$ ) influenced the counts of every group of studied microorganism, while the interactions packages x types of khoa, packages x intervals, packages x intervals x types of khoa did not significantly affect any count. The differences due to the types of packages were more significant ( $P<0.01$ ) in case of SPC and lipolytic counts compared to acid producers, proteolytic, chromogenic and Yeast & Mould counts ( $P<0.05$ ). There was no significant effect on the aerobic spore forming bacilli count due to the different types of packages.



Reddy *et.al.*, (1993) reported the effectiveness of antimicrobial agents [hisaplin and potassium sorbate] and commonly available packaging materials [aluminium foil, polyethylene and parchment paper] on microbial quality of khoa during storage at 37 and 5 degree C. Results showed that counts of mesophilic aerobes, yeast and fungi in khoa were reduced by the incorporation of 0.30% potassium sorbate (product wt. basis) and by packaging in aluminium foil.

Goyal & Rajorhia (1991) discussed the selection of packaging materials for indigenous Indian dairy products with respect to boosting sales and export. Hot filling (80-90 degree C) and casing khoa increased the shelf-life to 14 days at 37 degree C. Khoa packed in a 3-ply laminate of paper/Al-foil/LDPE or a 2-ply laminate of MST cellulose had a shelf-life of 10 days at 37 degree C, or 60 days when refrigerated; 4-ply laminate pouches of polypropylene/LDPE/Al-foil/LDPE extended the shelf-life of khoa to 14 days at 30 degree C and 75 days in cold storage. Packaging chhanna in MST cellulose/LDPE enhanced shelf-life by up to 3 days at 37 degree C and 20 days when refrigerated. The ideal packaging material for ghee was found to be flexible, impermeable to water vapour and mechanically strong. Flexible polyfilms and laminates are recommended for milk sweets, such as burfi and kalakand. Polystyrene cups are the most convenient packaging for indigenous fermented products, such as dahi, srikhand and chakka.

Goyal & Srinivasan (1989) prepared khoa from buffaloes' or cows' milk or purchased commercially, and stored at 4-5 degree C, 100% RH, either in cans or in flexible packaging (LDPE with MST cellulose, or LDPE with poster paper and (J a middle layer of 0.02-mm or 0.009-mm aluminium foil). Samples were analysed at the beginning of storage and after 20, 40 and 60 days for lipolytic organisms, aerobic sporeforming bacilli and yeasts and moulds. Initial counts of lipolytic organisms and aerobic sporeforming bacilli were highest in khoa made from buffaloes' milk. Commercial samples contained the maximum number of yeasts and moulds, possibly due to post-manufacture contamination. After 60 days, commercial samples generally had the highest counts of each type of microorganism investigated. The flexible packaging consisting of poster paper, aluminium foil and LDPE (55/60 g/m-2, 0.02 mm and 150 gauge, resp.) was judged to be the most effective for preventing microbial growth in khoa stored under the specified conditions.

Goyal & Srinivasan (1990) prepared khoa from buffaloes' or cows' milk or purchased commercial khoa samples were packed in 3 types of presterilized flexible packages (outer: poster paper (55/60 or 55/50 g/m<sup>2</sup>) or MST cellulose film; middle: Al foil (0.009 or 0.02 mm); inner: 150 gauge LDPE) and stored at (i) 37 plus/minus 0.5 degree C and 60% RH or at (ii) 4-5 degree C and 100% RH. Packages were tested for bursting strength using a pneumatic burst tester before filling and after emptying out the contents after 0, 5, 10 and 15 days of storage at (i) or 0, 20, 40 and 60 days of storage at (ii). Bursting strength (kg/cm<sup>2</sup>) decreased as storage progressed; decreases were greater for storage at (ii) than at (i). Type of khoa, storage time, type of packaging material and the interaction between packaging material and storage time significantly (P less than 0.01) affected bursting strength. Max. decrease in bursting strength during storage occurred with the material having thinner Al foil. The best material for storage of khoa between the other 2 package types depended on the storage conditions.

Dinakar & Sharma (1989) added formalin (40%) to khoa samples. Khoa was prepared from buffaloes' milk at 0.05, 0.10, 0.20, 0.25 or 0.30 ml/25 g of sample; it was stored for 5 months at 35 plus/minus 1 degree C. Addition of 0.20 ml formalin/25 g was most effective for controlling development of titratable acidity, volatile acidity and water-soluble proteins. No significant effects were observed on moisture, fat and total protein contents irrespective of formalin doses. Contents of vitamin A and C decreased in all cases. During storage, the rate of decrease in lactose content decreased with increasing formalin concentration, lactose contents were 19.54% in fresh khoa and 19.15 and 19.43%, respectively in samples preserved for 5 months with 0.05 and 0.30 ml formalin/25 g. Addition of 0.20-ml formalin/25 g was concluded to be more effective in preserving khoa samples for compositional analysis than the current recommended amount of 0.10 ml/25g.

Goyal & Srinivasan (1989) studied the effects of 3 different flexible packaging materials, (i) poster paper/Al foil/low-density polyethylene (LDPE) (55/60 g/m<sup>2</sup>, 0.02 mm and 150 gauge), (ii) poster paper/Al foil/LDPE (55/60 g/m<sup>2</sup>, 0.009 mm and 150 gauge), (iii) MST cellulose film/LDPE (30 g/m<sup>2</sup> and 150 gauge) and (iv) tin cans, on the chemical quality of 3 types of khoa samples, prepared in the laboratory from cows' milk or buffaloes' milk or purchased from a local market, when stored at 4-5 degree C at 100% RH for up to 60 days.

Khoa samples packaged in (i) showed minimum chemical changes during storage, followed by the samples packaged in (ii) then (iii). The 4 types of packages, the 3 types of khoa and storage period, each individually influenced the chemical quality of khoa.

**Goyal & Srinivasan (1988)** Samples of khoa freshly prepared from cows' and buffaloes' milks, and market samples of khoa, were packaged in the following pre-sterilized packages: (i) poster paper/Al foil/LDPE of 55/60 g/m<sup>2</sup>, 0.02 mm and 150 gauge, resp.; (ii) as (i), but with 0.009 mm Al foil; (iii) MST cellulose film/LDPE at 300 and 150 gauge, respectively; and (iv) tin cans. During storage for 60 days, the log standards plate count (SPC) of cows', buffaloes' and market khoa, respectively, increased from 3.648, 3.761 and 4.231/g to 5.299- 5.415, 5.371-5.446 and 5.954-6.075/g, the increase in each case being in the order (iv) greater than (iii) greater than (ii) greater than (i). Type of package, type of khoa and duration of storage each had a significant effect on log SPC, acid producer and proteolytic counts, whilst khoa type had a significant effect on log acid producer and proteolytic counts. A significant effect was also found for type of package, storage period and type of khoa on chromogenic count, which was higher initially in market than fresh khoa. The relative efficiency of packages in preventing microbial growth in khoa was (i) greater than (ii) greater than (iii) greater than (iv).

**Prajapati et.al., (1986)** Khoa was made from cows' milk with 0 (control), 30, 40 or 50% sugar, shaped into 20-25 g balls, wrapped in parchment and stored in cardboard boxes at room temperature. Khoa with 0, 30, 40 and 50% sugar, respectively had aw 0.925, 0.833, 0.794 and 0.780; during storage for 15 days, aw and moisture decreased in all samples. Shelf life of khoa was 3-4, 9-10, 12-14 and 15-17 days, respectively.

**Patel et. al., (1985)** 1000 p.p.m. Na<sub>2</sub>S<sub>2</sub>O<sub>5</sub> (T1) or K<sub>2</sub>S<sub>2</sub>O<sub>5</sub> (T2) was added to khoa at moisture levels of 25-35%. Moisture levels in control, T1 and T2 khoa, respectively, decreased from 29.5, 28.95 and 28.11% initially to 27.80, 25.79 and 26.03% after storage for 15 days at room temperature, acidity (as % lactic acid) increased correspondingly from 0.569, 0.890 and 0.944% initially to 0.996, 1.213 and 1.050% on day 15. Total S<sub>0</sub>2 level in control khoa decreased from 126.5 p.p.m. initially to 98.2 p.p.m. on day 2 and then increased to 227.2 p.p.m. on day 15, whilst in T1 and T2 khoa, respectively, it decreased steadily from 1839.5 and 1530.9 p.p.m.

initially to 1265.6 and 1116.2 p.p.m. on day 15. Proteolytic and lipolytic activities throughout storage were greater ( $P$  less than 0.05) in control samples, and peroxide values on day 15 were considerably higher in control samples. T1 and T2 significantly reduced ( $P$  less than 0.05) standard plate and yeast/mould counts, particularly after storage for greater than 3 days. The sulphurous flavour of treated khoa could be reduced by blending with fresh untreated khoa, or by heat treatment prior to its use in sweets such as peda and burfi.

**Gyanendra & Srinivasan (1982)** Samples of experimental khoa prepared from (i) cows' milk and (ii) buffaloes' milk, and (iii) market samples of fresh khoa, were packaged as follows: P1, 'poster' paper (PP)/Al foil/low density polyethylene (LDPE) (55/60 g/m<sup>2</sup>, 0.02 mm and 150 gauge respectively.); P2, as P1 but with 0.009 mm Al foil; P3, MST cellulose film/LDPE (300 and 150 gauge respectively.); and P4, tin cans. Sensory evaluations showed that (i) and (ii) were preferred to (iii) irrespective of type of package or storage conditions. Order of preference for type of packaging was P4 greater than P1 greater than P2 greater than P3 when stored at 37 degree C and 60% RH, and only (ii) khoa packaged in P4 was still acceptable at 15 days. Corresponding preference for khoa stored at 4-5 degree C and 100% RH was P1 greater than P2 greater than P3 greater than P4, and all samples remained acceptable for greater than 40 days; khoa made from (i) and packaged in P1 or P2 and all khoa made from (ii) was acceptable for up to 60 days. Sensory quality was affected ( $P$  less than 0.01) by type of package, type of khoa and duration of storage.

### **Rheological Properties**

Khoa has a granular texture consisting of protein granules with several hundred of micrometers in diameter, the granules consist of intact and partially fused casein micelles and non micellar protein; the fresh product is slightly coarse in the mouth. Large aggregate of lactose crystals develops in the inter-granular space in un-worked Khoa during storage. Working of Khoa markedly reduces the dimensions of protein granules and the inter-granular wide space and produces large amount of fat globule membrane fragments. Individual lactose crystals in worked Khoa stored at 20° C for 48 hours were more uniformly distributed compared to Khoa. Storage did not increase the sandiness in worked Khoa and sensory evaluation rated this product markedly smoother than the un-worked product. Instron measurement showed that

working significantly decreased the hardness and springiness but increased the adhesiveness and cohesiveness. An increase in total solids was also accompanied by a considerable increase in hardness, gumminess and chewiness but a decrease in cohesiveness of Khoa. Water dispersible protein has the opposite effect on all these properties except cohesiveness (Patel *et al*, 1990a). Patel *et al* (1990) has found a positive and significant correlation in total solids and hardness of Khoa. Microstructure and texture of Khoa has been studied in detail (Patil *et al*, 1992). However, milk acidity and free fat content in Khoa had no effect on rheological properties of Khoa.

Adhikari *et al.*, (1994) reported the Interrelationships between texture, composition, and microstructure of khoa and gulabjamans made from buffaloes' milk was studied. Instron's hardness, gumminess, and chewiness were negatively correlated with moisture and fat contents, but positively correlated with protein, lactose, added carbohydrates, ash, and Ca contents for both khoa and gulabjamans. Cohesiveness was moderately influenced by composition, while no correlation was found between composition and springiness for both products. Significant interrelationships between hardness and cohesiveness and between gumminess and chewiness were observed. Texture and composition of both products were well correlated with their ultrastructural attributes, as determined by TEM.

Patil *et al.*, (1992) Khoa, a partially dehydrated milk product indigenous to India, was prepared from buffalo milk by boiling it vigorously in an open pan and reducing its volume to approximately 25% within 30 minute. The hot semi-solid product (khoa pat) was held at 20 degree C for 3 h (fresh, cooled khoa) or 48 h (stored khoa); the products were either worked with a pestle in a mortar for 5 min or were left without working. Structural features of khoa were studied by light microscopy and EM. Freshly prepared cooled khoa had a granular structure consisting of protein granules several hundred  $\mu$ m in diameter. The granules consisted of intact and partly fused casein micelles and non-micellar protein. The fresh product was only slightly sandy in the mouth. Large aggregates of lactose crystals developed in the inter-granular spaces in unworked khoa during storage and sandiness in the stored product was markedly increased. Working reduced the dimensions of the protein granules and the intergranular void spaces and produced large amounts of fat globule membrane fragments. Individual lactose crystals in worked khoa stored at 20 degree

C for 48 h were more uniformly distributed than in unworked khoa. Storage did not increase sandiness in the worked product; sensory analysis rated this product to be markedly smoother than unworked stored khoa. Instrumental measurements showed that working significantly decreased hardness and springiness and increased adhesiveness and, to a smaller extent, cohesiveness.

**Patel et. al., (1992)** Texture of khoa made from buffaloes' milk using a steam kettle was assessed and compared to khoa obtained by traditional processing. The steam kettle process yielded a product that was significantly harder, springier, gummier and chewier but less adhesive than that from the simulated traditional process. Sensory evaluation revealed that firmness and chewiness were higher for traditionally processed khoa. Khoa made by the steam kettle process was more desirable with respect to texture, having greater smoothness and less crumbliness. High-moisture khoa (dhap) was softer and smoother and less gummy and chewy than low-moisture khoa (pindi). Interactions of processing with moisture and milk acidity were statistically non-significant for all texture parameters except sensory chewiness.

**Gupta et. al., (1990)** An increase in TS was accompanied by a considerable increase in Instron hardness, gumminess and chewiness, but a decrease in cohesiveness of khoa [prepared with buffaloes' pooled milk standardized to a fat-SNF ratio of 0.6; the resulting product contained (%) 56.2-71.9 TS, 20.8-28.0 fat, 3.2-13.5 free fat, 14.9-18.9 total protein and 8.5-28.7 water dispersible protein (WDP)]. WDP had the opposite effect, although its effect on cohesiveness was non-significant. Acidity and free fat content of khoa did not show any significant correlations with texture profile (TP) parameters. Their inclusion in regression analysis made a small but perceivable improvement in predictability of cohesiveness and chewiness. Significant interrelationships among TP parameters, particularly between hardness and cohesiveness, gumminess and chewiness, and also between cohesiveness and all other parameters indicated that 1 or 2 most important TP parameters could serve as an index of the texture profile of khoa. Adhesiveness and springiness of khoa generally showed poor correlations with compositional characteristics as also with other TP parameters.

**Sawhney et. al., (1984)** 3 types of khoa (pindi, dhap and danedar) were prepared at 116.2 degree , 126.6 degree and 134.2 degree C; at different stages of preparation, samples were examined in a constant temperature Capillary tube

viscometer. The consistency coefficient, ( $m$ ) of all 3 types of khoa remained constant up to 30% TS; above this concentration, it increased, particularly in the TS range 40-60%. The flow behaviour index ( $n$ ) also remained constant for all 3 types of khoa up to 30-35% TS; it then decreased rapidly at higher TS contents, particularly in danedar khoa. Results indicated that khoa at all stages of concentration is a pseudo-plastic non-Newtonian food product. Temperature at which the khoa was prepared had no effect on  $m$  or  $n$  values in the initial stages of preparation, but after TS reached 38%, the  $m$  value was higher and  $n$  values lower for khoa prepared at the higher temperature. The effect of temperature was more pronounced with pindi khoa because of its higher concentration.

### **Economics of Khoa Manufacture**

Chand *et.al.*, (1994) conducted the study on 60 sweet making units in Ganga Nagar during 1991 using multistage stratified random sampling technique. The study revealed that on an average an investment of Rs.4.58 lakhs was required to set a unit. The investment varied from Rs 2.30 lakhs on small units to Rs.6.68 lakhs on large units. The study further revealed that cost of production of burfi, Kalakand, Milkcake & Katli which in the first category was Rs.23.25, or maida like Gulab Jamun & Gajjar pak, the cost production was Rs.18.32 & Rs.18.47 respectively. The third category of products namely cream burfi, coconut burfi, fruit cake, Pista burfi and Chocolate burfi which was produced for the affluent groups, the cost of production was Rs.35.73, Rs.33.17, Rs.40.04, Rs.32.36 & Rs.29.27, respectively. The study further revealed that the profit margin in the first category varied from Rs.12/- to 14/-. In the second category the net profit was observed to vary from Rs.5/- to Rs.17/-. The third category was considered to have profit, which varied from Rs.14/- to Rs.19/-

### **Mechanized Method**

Atmospheric roller drivers which were hitherto used for the manufacture of milk powders have been replaced by the spray drier are lying idle. Attempts were, therefore, made to examine the feasibility of preparing khoa on the roller drier by adjusting the process variables such as steam pressure, roller speed, degree of concentration of milk, flow rate of the concentrated milk and manipulating the distance between the rollers and the scraping blades.

Vacuum concentrated milk with 50% total solids preheated to 74° C for 10 mins was found suitable for khoa-making on roller driers at 25-30 psi. A kneader is place at the outlet of the roller drier to make homogeneous mass of khoa.

Most of the attempts in development of khoa making process have been directed towards development of plant, which can enable the industrialization of khoa making process through mechanization. A semi -continuous khoa-making machine was developed by **Bannerjee *et al.*(1976)**. The plant consisted of a scraped surface heat exchanger and two open semi-jacketed pans with reciprocating spring loaded scrapers.

Milk (12-13% total solids) was pumped in the scraped surface heat exchanger for preheating and concentration to 30-35% total solids. The first stage of the open semi-jacketed pan further concentrated the milk to 50-55% total solids was achieved in the second pan. The equipment had a capacity of 50 litres of milk per hour.

**Sawhney *et al* (1980)** mechanized the traditional batch process by providing a semi-jacket, shallow open pan and using swinging hanger type scraper for stirring during the desiccation process. The use of steam for heating permitted a better control of temperature.

**More, (1985)** designed semi-mechanized scraper assembly, comprising of spring loaded blades rubber boots, and a central shaft. Both these processes remained essentially batch processes. The major problem encountered in these processes was the un-stability of the process and absence of typical flavour, texture, taste and other physio-chemical and functional attributes. Membrane processes for pre-concentration have also been tried followed by desiccation in open vats. Such processes have not been successful for whole milk because of fouling of membrane due to milk fat. Pre-concentration of skim milk followed by standardization of fat with cream and desiccation is not only cumbersome but also results in inferior quality product.

Conthern convap system developed by Alfa Laval also had been used for manufacturing of Khoa. A conical vat machine has recently been developed in NDRI Karnal. The plant does not give uniform quality product and results in high losses.

The latest innovation is the development of an inclined scraped surface heat exchanger for continuous Khoa making by the NDDB.



The plant comprises of a balance tank, a positive displacement pump and an Inclined Scraped Surface Heat Exchanger (ISSHE). Milk concentrate used as feed is pumped into the ISSHE at desired flow rate by adjusting the capacity of the feed pump.

**Cheryan *et. al.*, (1987)** compared the three methods of pre-concentrating whole milk for manufacture of khoa. To pre-concentrate milk from 15 to 31% TS, a mechanically-scraped open-pan kettle required 455 kcal/kg milk, while a double-effect vacuum evaporator consumed less than 50% of that energy and a mechanical vapour recompression/single-effect evaporator required less than 33% of that energy. Reverse osmosis using a batch dual-pump or a continuous 3-stage recycle system was most economical, requiring less than 10 kcal/kg milk, plus about 15 kcal/kg milk for HTST pasteurization. This represented a saving of greater than 400 kcal/kg milk compared with scraped kettle and greater than 100 kcal/kg milk compared with evaporators.

**Rajorhia *et. al.*, (1991)** compared the performances of 4 mechanized systems of khoa making, i.e., inclined scraped surface heat exchanger (ISSHE), conical vat, contherm-convap heat exchanger and roller drier. Units were run under standardized conditions and the product obtained after different intervals was analysed for chemical composition, sensory quality and rheological properties. Pertinent operational features were also critically observed. Sensory characteristics of khoa prepared by ISSHE were similar to those of the traditional product and chemical composition and rheological properties of khoa maintained uniformity during continuous system operation for about 10 h. Quality of khoa prepared by the other 3 systems was inconsistent in composition, texture and colour during operation and sensory quality was inferior as compared with traditional khoa. ISSHE was compact and simple [and suitable for] continuous manufacture of greater than 300 kg of khoa in 1 shift of 8 h.

**Sharma *et. al.*, (1990)** Khoa quality is influenced by various intrinsic and processing parameters. [Effects were studied of milk fat/SNF ratio (0.005-1.169), holding period (101-103 degree C for 0-15 min), homogenization (pressure 0-250 kg/cm<sup>2</sup>) and citric acid addition (0-0.05% w/v, liquid milk basis) on the colour, texture, sweetness, flavour, hardness and overall acceptability of khoa made in a horizontal drum drier.

Acceptability was greatest for samples prepared from milks having fat SNF ratios of 0.316, 0.546 or 0.659. Colour increased with increase in the fat % used. Similarly, an increase in the holding period led to greater acceptability of the product, in spite of the fact that the colour was seen to shift slightly towards brown. Homogenization and citric acid addition reduced colour development, but there was poor acceptability of these khoa samples. Homogenization led to sticky product and citric acid at greater than 0.02% resulted in a sour product. It is concluded that khoa of satisfactory quality can be manufactured from milk having fat SNF ratio of 0.549-0.659 with a holding at 101-103 degree C for 10-12 min without using citric acid or homogenization.

**Singh & Rajorhia (1989)** A standard method for production of khoa by roller drying was developed, using standardized cows' milk (4% fat and 8.5% SNF) or buffaloes' milk (5% fat and 9.0% SNF), after vacuum concentration to 50% TS, preheating to 74 degree C for 10 min and controlling milk flow rate, speed of roller, steam pressure and distance between knives and roller drums. Khoa prepared by roller drying compared well in flavour, texture and chemical composition with that of traditional khoa using small-scale production methods. Khoa had a shelf-life of less than 5 days at 30 degree C, and 15 days at refrigeration temp. Roller driers can be successfully employed for large-scale production of khoa in combination with a suitable kneading device.

**Bhadania et. al., (1986)** Khoa was prepared from unhomogenized and homogenized buffalo milk (5.0% fat) by concentration to 50-55% TS in a double jacketed stainless steel kettle, followed by drying in a laboratory scale roller dryer. Organoleptic evaluation showed that colour, body and texture were comparable to those of khoa made by the conventional method, whereas flavour and appearance were inferior. Homogenization did not improve flavour and taste, but did enhance colour of the khoa. Overall the roller-dried khoa was acceptable.

### **New approaches to Khoa manufacture**

**Dharam & Munir-Cheryan (1987)** reported that a process was developed for manufacture of khoa using reverse osmosis (RO) to preconcentrate the milk. Flux in spiral-wound cellulose acetate 8 membranes was pressure-dependent up to 27 kg/cm<sup>2</sup> and then became independent of pressure. No permeation was observed until a

pressure of 6-kg cm<sup>-2</sup> was applied, due to the osmotic pressure of milk. Flow rate affected flux only in the pressure-independent region. The average flux when concentrating cows' milk from 12.5 to 31% TS was 8.10 l m<sup>-2</sup> h<sup>-1</sup> at 30 degree C. Khoa manufactured from preconcentrate (31% TS) whole milk was typical in flavour and texture. The mineral and ash contents of RO-khoa were slightly lower due to permeation of these compounds through the RO membrane. The overall economics of continuous khoa manufacture based on RO are attractive, primarily because of the large savings in energy compared with traditional open-pan boilers.

**Patel et. al., (1993)** Cows' milk khoa is generally unacceptable due to its smooth and pasty body, sandy texture and salty taste. The researcher investigated the potential development of a desirable grainy texture in cows' milk khoa with the addition of whey protein concentrate (WPC). Khoa containing WPC showed improved sensory properties over the control khoa, and compared well with commercial khoa. A lower TS content in WPC-containing khoa was necessary to counteract the adverse effect of WPC on instron texture parameters. It is concluded that a good quality khoa with reduced TS content can be prepared by incorporating 5% WPC into cows' milk khoa during preparation. This method enables acceptable khoa to be manufactured in places where buffaloes' milk is not available.

**Kumar et. al., (1994)** Khoa was manufactured by a batch method from buffalo whole milk (6% fat) that had been preheated to 60°C, cooled to 50°C, and concentrated (i) 1.5- and (ii) 2-fold by reverse osmosis. Mean composition of (i), (ii) and control (prepared from standardized fresh milk) khoa respectively was as follows: moisture, 42.5, 43.85 and 32.05%; fat, 21.28, 21.08 and 22.29%; fat in DM, 37.54, 37.03 and 32.86%; and free fat, 20.26, 12.06 and 54.54% of total fat. Rheological properties, measured with an Instron Universal testing machine, showed that hardness, springiness, gumminess, chewiness and cohesiveness were in the order control > (i) > (ii) khoa. Flavour of (i) khoa was similar to that of control khoa and superior (P<0.01) to that of (ii) khoa, and body/texture of both (i) and (ii) khoa was inferior (P <0.01) to that of control khoa, but there were no significant differences in colour/appearance. Total organoleptic score of (i), (ii) and control khoa respectively was 94.58, 83.57 and 97.56. It is concluded that khoa of acceptable quality can be made from milk concentrated 1.5-fold by reverse osmosis.

## Various products from Khoa

**Prajapati *et. al.*, (1994)** Gulabjaman is an Indian dairy dessert prepared from khoa. Effects of incorporating trisodium citrate at 0.5 or 0.8% milk solids into buffaloes' milk khoa or dough on properties of gulabjaman were investigated. Chemical composition and rheological properties (penetration value and springiness) of gulabjamans were not significantly affected by the use of trisodium citrate, whereas flavour and sugar absorption characteristics improved significantly under similar conditions. Softness and sensory qualities of gulabjamans were improved by addition of 0.5% trisodium citrate to milk during khoa manufacture.

**Rehman *et. al.*, (1994)** Performance of khoa as a milk solids source in ice cream was tested by replacing 250, 500, 750 and 1000 g/kg of condensed milk in control ice cream [with khoa]. Proximate composition was little affected by inclusion of khoa at any level tested. At levels of inclusion greater than 250 g/kg, viscosity of both fresh and aged experimental mixes was significantly ( $P$  less than 0.05) increased compared with controls. Some mixes containing khoa appeared slightly off-white, but there were no overall differences from control. Control and experimental mixes were identical in whipping capacity and overrun. In organoleptic evaluation, colour score of ice cream declined significantly ( $P$  less than 0.05) when 750 or 1000 g/kg of condensed milk was replaced with khoa. Ice creams containing khoa were equivalent or superior to controls in flavour. In objective tests, experimental ice creams showed significantly ( $P$  less than 0.05) faster meltdown compared with control, but no differences were found in subjective assessments. Results suggest that khoa can be used successfully as a milk solids source for ice cream without any serious adverse effects on quality, the only problem being the dull colour.

**Deshmukh *et. al.*, (1993)** Gulabjamans, a popular Indian sweet, are prepared by addition of sugar or jaggery to khoa (condensed milk solids), together with maida and baking powder. Effect of homogenization of milk in the preparation of khoa on quality of the final gulabjamans was studied. Khoa made from un homogenized and homogenized milk was blended with maida in the ratio 3:1; baking powder was added at levels of 0, 0.02, 0.05, 0.08 and 0.11%. Gulabjamans prepared from un homogenized milk khoa with 0.08% baking powder was the most acceptable product. Milk homogenization did not improve the quality of gulabjamans.

**Sachdeva & Rajorhia (1982)** Market samples of burfi obtained from Delhi and Karnal showed a wide variation in composition both within and between the 2 market sources. The 12 samples from Delhi had higher mean moisture, protein, fat and lactose contents and lower mean lactose acidity and sucrose contents than the 12 samples from Karnal. A highly acceptable burfi was prepared as follows: buffaloes' milk standardized to 6% fat was converted to khoa, 25-30% sugar was added while the khoa was still hot, and the mixture whipped with a wooden spoon. Burfi prepared from cows' milk with 4.5% fat was sticky and gummy, and 30-35% sugar was required to give an acceptable product. Shelf-life of burfi packaged in parchment was 10 days at 30 degree C and 50 days at 5 degree C; when packaged in tins, shelf-life was 15 days at 30 degree C and greater than 105 days at 5 degree C. The major causes of spoilage were fat oxidation and mould growth. Addition of 0.015% saffron to burfi improved its microbiological quality.

**Boghra & Rajorhia (1982)** Khoa was made from cows' (4.6% fat) and buffaloes' (5% fat) milks directly (controls) and after pre-concentration by evaporation to (i) 31% and (ii) 40% TS. Pre-concentration of the milk had little effect on fat %, TS % or acidity of the khoa. Free fat (as % total fat) in khoa prepared from control, (i) and (ii) milk respectively was 66.79, 66.33 and 63.67 in cows' khoa and 82.8, 76.9 and 66.53 in buffaloes' khoa. 5-hydroxymethyl furfural values and p-dimethylaminobenzaldehyde reactivity decreased as the level of preconcentration of the milk increased. Mean time required to convert milk into khoa was 15, 6 and 4 min for control, (i) and (ii) milks respectively. Flavour scores for khoa made from (i) were comparable to those of controls; uses of (ii) resulted in lower flavour scores and also slight stickiness in khoa made from cows' milk.

## PEDA

Associated with the celebration of happy, auspicious occasions, peda is popular almost all over India. Various forms of Peda are made in accordance with regional preferences.

In a shallow pan, all the ingredients, viz., khoa, sugar, aromatic spices, nuts etc. are added, and heating done with constants stirring till typical colour and flavour develops.

This is patted into a compact mass in shape of balls with flattened top and bottom ends.

Peda or Doodh peda is prepared on a small-scale by halwais using khoa as the base material mixed with sugar and flavourings. The quantity of peda produced in India exceeds any other indigenous milk based sweets using khoa as the raw material. Peda is traditionally prepared by mixing khoa and sugar in the ratio of 3:1 Peda is whitish yellow in colour and has a coarse, grainy texture. Kesar (saffron) peda is one of the preferred pedas in which saffron is mixed for added flavour and colour.

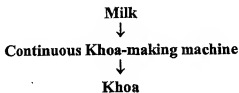
## **METHODS OF PREPARATION OF PEDA**

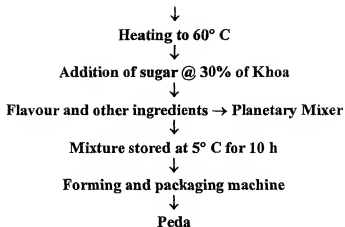
### **a. Traditional Method**

It differs slightly depending on the type of Pedas, basically the method is identical to that of Burfi preparation wherein a mixture of Khoa and sugar is heated at low fire till desired texture is attained. Peda is made into round balls of about 20 - 25g size, normally by rolling between the palms. The product may also be formed into different shapes and sizes using different dies/moulds. Peda is usually packed in paper board / boxes having a parchment paper liner or grease proof paper liner (Reddy, 1985). In other approach, 168 kg of Peda can be prepared from 600 litres of buffalo milk in a shift of 8h, on a set of six crude oil combustion furnaces. In this case 5 lit of milk is taken each time in a pan and when milk comes to boiling, 450g sugar is added and subsequently Peda is prepared as described above. This method is adopted in rural milk centres in Kutch district of Gujarat. In Mathura district of U.P, Khoa is first cooked to brown colour in Ghee and then Peda is prepared from it by blending sugar and other addition.

### **b. Industrial Method**

In Sugam Dairy Baroda, Kesar Peda is prepared by adopting a large scale mechanized process. The flow diagram of the process is given below (Banerjee, 1997).





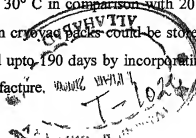
## **Upgradation of Technology for Khoa Sweets**

In view of the growing demands for khoa based sweets, the dairy plants in India are planning to diversify their production functions to convert the seasonal surplus milk into milk sweets. However, until recently large scale manufacturing technology was not available for adoption. Suitable methods have been developed for the manufacture of burfi and peda by adopting and modifying the unit processed and equipment already available in dairy and food processing industries.

The production of burfi from concentrated milk required vacuum evaporation of whole milk to about 35% total solids, followed by further evaporation in a scraped surface heat exchanger using 1.5 kg/cm<sup>2</sup> steam pressure to a solid level of 75%, then cooling to about 50° C and addition of 20 parts cane sugar by weight of concentrated milk. The mix is kneaded and whipped to obtain a smooth paste. A standard method for production of burfi and SMP was also developed. Replacement of 50% cane sugar with corn syrup (42DE) improved the gloss and texture of the sweet besides extending its shelf life and reducing the sweet taste.

The studies on extension of shelf-life indicated that an equilibrium relative humidity (ERH) of 70% for burfi having moisture content of about 15% was optimum for storage at 30° C. Higher ERH encouraged the mould growth, whereas, lower ERH impaired the textural quality. Burfi samples packaged in pre-sterilized cryovac pouches remained acceptable upto 30 days at 30° C in comparison with 20 days in unsterilized pouches. At 5° C, burfi samples in cryovac packs could be stored safely for 180 days. The shelf life could be extended upto 190 days by incorporating 0.1% sorbic acid (w/w) during the last stage of manufacture.

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2894



The technology for large-scale production of peda using concentrated milk and skimmed milk powder was standardized and the shelf-life extension studies also conducted. The cost estimation revealed that manufacturing burfi and peda from concentrated milk was more cost effective as compared with the conventional and SMP processes.

### **Shelf-life of Peda**

The Shelf life of Peda under normal packaging conditions at room temperature is about 2 weeks. It can be increased to about 40 days by packaging in pre-sterilized shrink-wrap. Replacement of 50% cane sugar with corn syrup reduces the water activity to about 0.6 and enhances the shelf life up to 45 days in addition to improving the body and texture. Addition of 0.1% sorbic acid, at the end of manufacturing process, has been found to extend the shelf life of Peda upto 45 days at 30° C. Packaging of Peda samples in multilayer transparent laminates with oxygen scavenger extended the shelf-life up to 2 months at 37° C, 5 months at ambient temperature and 6 months at 20° C (Kumar *et al*, 1997).

### **Chemical Quality of Peda**

Reddy & Rajorhia (1990) determined the equilibrium RH (E.R.H.) of peda and burfi at 30°C by the wt equilibrium method. Peda & burfi was prepared from khoa and sugar, and having initial moisture content of 10.33 and 15.15% respectively. Optimum ERH for storage of peda was 60% (reached in 12 days), at which point the equilibrium moisture content was 10.25%. Optimum ERH for burfi was 70% (reached in 7 days), at which point the equilibrium moisture content was 14.86%. With both products, a higher ERH encouraged mould growth whilst a lower ERH resulted in a hard, dry product with a tendency to brown discoloration.

Gothwal & Shukla (1995) studied the effects of addition of refined wheat flour (maida) and sugar on browning and physicochemical properties of cows' and buffaloes' milk, pooled milk samples, khoa and khoa-based dairy products (burfee, kalakand, milk cake, gulabjaman, milk pera). Addition of maida at an 8% level increased the browning index by 20-22% during heat treatment in both cows' and buffaloes' milk. Addition of maida at 10% increased the browning *U* index by 13% in burfi, kalakand and milk pera, and by 18% in milk cake. Milk samples containing added sugar levels of 6, 8 and 10%, and sterilized at 1.05 kg/cm<sup>2</sup> for 15 min, showed



no browning, although prolonged heating caused intense browning as compared to samples with no added sugar. Addition of sugar at 15-35% (based on the wt. of khoa) produced less browning in burfi and kalakand than when sugar was added at 4%. Different mix formulations were found to alter protein, fat and total carbohydrate contents of gulabjaman. The frying temperature of gulabjaman had a significant effect of fat uptake. Higher TS levels tended to increase browning in khoa and khoa-based sweets.

Nusrath *et al.*, (1987) Lactose content was determined in sweets based on chhana (rasogolla, rasbhari, apple, rajbhog), khoa (burfi, pedha) and khoa-chhana mixtures (anarkali, champakali and sandwich). Lactose was absent in chhana-based sweets, but comprised 5.1-11.9% of khoa-based sweets and 2.6-5.0% of khoa-chhana preparations.

### **Microbiology of Peda**

Garg & Mandokhot (1984) 28 burfi and 38 pera samples, from various manufacturers and shops in Hissar and Hansi, had standard plate counts ranging from 530 to 71 000/g and from 1100 to 560 000/g, respectively. 11 and 15 samples contained coliforms (determined on eosin/methylene blue agar), 0 and 1 sample contained *Escherichia coli*, and 5 and 19 contained faecal streptococci. Composition of the microflora of individual samples varied considerably, but the mean total flora of burfi and pera samples, included: *Bacillus* spp., 41.2 and 22.3%; *Staphylococcus* spp., 31.8 and 32.8%; *Micrococcus* spp., 23.5 and 27.7%; unidentified Gram-positive cocci, 0.1 and 11.7%; faecal streptococci, 0.8 and 0.7%; and total Gram-positive organisms, 98.7 and 98.9%, respectively. Few yeasts/moulds were found. Mean chemical composition of 16 burfi and 16 pera samples, resp., was 13.88 and 14.99% moisture, 22.52 and 22.06% lipid and 12.88 and 13.77% protein; pH range was 5.95-7.0 and 5.60-7.05, respectively.

Ghodeker *et al* (1980) 75 khoa, 60 burfi and 50 pera samples respectively from local halwai shops, had initial counts of 6000, 5000 and 5500 total bacteria/g, 20, 40 and 40 yeasts/g and 10, 20 and 30 moulds/g, and 0.21, 0.17 and 0.15% titratable acidity. When stored at various temperature. Khoa samples became sour after 2 days at 30 degree and 37 degree C, 3 days at 22 degree C, and 7 days at 5-7 degree C; burfi and pera samples became sour after 14 days at 30 degree and 37

degree C, 21 days at 22 degree C, or 30 days at 5-7 degree C. Increase in acidity resulting from growth of acid-producing bacteria provided a favourable environment for growth of yeasts and moulds. *Saccharomyces*, *Candida*, *Rhodotorula* and *Torulopsis* spp. were the predominant yeast isolates whilst the predominant moulds were *Penicillium*, *Aspergillus* and *Geotrichum* spp. Presence of moulds was indicative of unhygienic conditions during manufacture and storage.

**Gothwal & Shukla (1995)** studied the effects of addition of refined wheat flour (maida) and sugar on browning and physicochemical properties of cows' and buffaloes' milk, pooled milk samples, khoa and khoa-based dairy products (burfee, kalakand, milk cake, gulabjaman, milk pera). Addition of maida at an 8% level increased the browning index by 20-22% during heat treatment in both cows' and buffaloes' milk. Addition of maida at 10% increased the browning *U* index by 13% in burfi, kalakand and milk pera, and by 18% in milk cake. Milk samples containing added sugar levels of 6, 8 and 10%, and sterilized at 1.05 kg/cm<sup>2</sup> for 15 min, showed no browning, although prolonged heating caused intense browning as compared to samples with no added sugar. Addition of sugar at 15-35% (based on the wt. of khoa) produced less browning in burfi and kalakand than when sugar was added at 4%. Different mix formulations were found to alter protein, fat and total carbohydrate contents of gulabjaman. The frying temperature of gulabjaman had a significant effect of fat uptake. Higher TS levels tended to increase browning in khoa and khoa-based sweets.

## CHHANA

### Introduction

Chhana is an indigenous milk product obtained by acid coagulation of hot milk followed by draining of whey. The coagulum is collected in a cloth and hung on a peg to drain off the whey without applying pressure. Channa is usually prepared by mixing old channa whey with boiling hot milk. The dilution with whey also contributes to making a smooth coagulum, which is considered desirable for making many Bengali sweets. Channa is widely used, in the eastern parts of India and Bangladesh, for the preparation of many milk based sweets.

According to **Prevention of Food Adulteration Rules (1955)** the product shall contain not more than 70% moisture and not less than 50% fat on dry matter basis. Skim milk chhana, shall contain not more than 13.0% fat of the dry matter. Chhana is used as a base for the preparation of a variety of sweetmeats like sandesh, rasogolla, cham-cham, ras-malai, pantooa, etc. The production of chhana is confined mostly to the eastern region of the country, notably West Bengal, Bihar and Orrisa. About 4% of the total milk produced in India are converted into chhana (**Aneja et al., 1982**).

### **Size of the industry**

Chhana is a product of acid coagulation of hot milk and draining out of whey, It is important and is of great significance as it forms the base for sweets such as rasogollas, sandesh and kalakand. It is estimated that approximately 12 lakh tonnes of chhana. valued at Rs.600 crores is produced in India.

### **Definition**

Chhana refers to milk-solids obtained by acid coagulation of boiled hot milk and subsequent drainage of whey. According to the **P.F.A.rules (1976)**, Chhana is the product obtained from cow or buffalo milk or a combination thereof by precipitation with sour milk, lactic acid or citric acid. It should not contain more than 70 percent moisture, and the milk fat should not contain less than 50 percent of the dry matter.

### **Traditional Method**

Traditionally Chhana is prepared by boiling about 20-40 liters of cow or mixed milk in an iron karahi on a coal or fire wood chullah. Milk is allowed to cool to about 80°C-85°C and coagulated in small installment while gently stirring the contents with the help of a ladle. The process is continued until all the milk gets precipitated in lumps, which settle down at the bottom. The clear whey floating on the top is filtered through a muslin cloth.

Chhana shows wide variations in physical, chemical and microbiological qualities. In most investigations, chhana was prepared from small quantity of milk by the traditional method.

Typically, cow milk is taken in a boiling pan (2-40 litres/batch) and is coagulated at high temperature using sour whey, but some organic acids may also be

used, Whey is then drained off by straining through a cloth. The Recovery of total solids is about 61.4 percent, of fat 99.0 percent and protein 93.6 percent corresponding to the yield of 20.4 percent (Jagtap and Shukla, 1972).

### Composition of Chhana

The approximate composition of chhana is Moisture 50-55 percent; fat 22-26 percent; protein 15-20 percent; lactose 2.0-2.5 percent, and ash 1.8-2.2 percent. Cow's milk with 4.0% fat and 8.6% SNF produced chhana, which was highly suitable for sandesh and rasogolla. **De and Ray (1954)** indicated that a SNF/Fat ratio of 2.1 is very useful for sweetmeat preparations. Observations of **Singh and Ray (1977)** and **Kawal (1979)** revealed that the type of coagulants did not have any appreciable effect on the composition of chhana while **Sen (1986)** found significant difference in moisture content between calcium lactate and citric acid chhana. **Kumar and Srinivasan (1982a)** found much difference in the average composition of chhana prepared from cow milk, buffalo milk and those of market samples. Wide variations in the moisture content of chhana ranging from 51.6 to 62.3% have been reported. Surprisingly, not a single chhana sample was found to approach the higher moisture limit prescribed under the **PFA rules** (i.e. 70% moisture). Apparently, **PFA rule** in respect of moisture content in chhana needs to be reviewed. Market samples generally contains lower fat content than the laboratory samples suggesting that milk of low fat content or partially skimmed is used for chhana making.

Channa has the same legal requirements as paneer, in India however Chhana differs from Paneer, in that no pressure is applied to remove the whey.

**A Typical channa has the following composition, on dry basis:**

	Buffalo	Cow
<b>Fat %</b>	3.05	61.0
<b>Protein %</b>	37.0	30.0
<b>Lactose %</b>	4.6	4.8
<b>Ash %</b>	4.4	4.1

## Factors affecting the quality

The body and texture of chhana is influenced by the type and quality of milk, conditions of coagulation, method of stirring and straining, amount of milk solids lost in whey and the moisture retention in the final product.

### a. Type of milk

Different type of milk have been made use of, to convert it to chhana. Every type of milk have exerted their influence on the quality of chhana.

Buffaloes' milk produced a significantly higher yield of chhana than cows' and goats' milk. Chhana prepared from buffalo's milk had hard body and coarse texture. Cows' and Goats' milk produced chhana with soft body and smooth texture. Chhana from cows' and buffaloes' milk had acceptable flavour whereas that from goats' milk was slightly acidic.

### Cow milk

Cow milk is better suited for Chhana-making because it produces Chhana with soft body and smooth texture, which is better for making sweets. **Boghra (1988)** found that chemical quality of Chhana was largely dependent on the initial composition of milk, percentage of moisture retained in the product and losses of milk solids in the whey.

**De and Ray (1954)** observed that cow milk produces chhana with moist surface, light yellow color, soft body, smooth texture and mildly acidic flavour. Cow milk chhana's more suitable for Bengali sweet preparation than buffalo milk chhana, the latter being hard in body and coarse in texture, besides having whitish colour and greasy surface. Sweets prepared from buffalo milk chhana are comparatively hard, coarse and less spongy (**Date et al. 1958; Jagtiani et al., 1960; Kundu and De, 1972; Kanawjia 1975; Gajendran 1976; Soni et al., 1980; Ahmed et al., 1981**).

**Jonkman & Das (1993)** studied the conditions for manufacture of chhana from cows' low fat milk with the aim of optimizing the production process. Heat treatment of milk prior to acidification, coagulation temperature, acidity of the milk-acid mixture, and residence time of the coagulum before separation were studied. Chhana with good texture was obtained using heat treatment at 95 degree C, coagulation temperature 70° C, 0.522% acidity and 8 minute residence time, maximum recovery of milk solids (48.2%) was obtained.

## Goat milk

**Moorthy and Rao (1982)** were successful in preparing rasogolla from goat milk chhana using lactic acid as coagulant. **Sharma *et al* (1998)** The yield and chemical quality of chhana, prepared from the milk of Jamnapari and Barbari goats, as influenced by coagulant concentration (1-5%), and temperature of coagulation (70-90°C), were investigated. The coagulants, sour whey and citric acid, resulted in higher yield, while tartaric acid and lactic acid gave lower yield. The percentage yield was greater from Jamnapari milk than from Barbari milk. 1-% coagulant and coagulation at 80°C gave maximum yield. Chemical analysis indicated that Barbari goat milk chhana had higher moisture content. Chhana from Jamnapari milk had a higher fat and lactose content but a lower protein and mineral content than Barbari goat milk chhana. The type of coagulant concentrations and temperature at coagulation also influenced the chemical quality of chhana. While citric acid caused higher moisture retention but lower fat, protein and mineral contents in Jamnapari milk chhana, the other coagulants (lactic acid, tartaric acid and sour whey) resulted in higher moisture but lower fat and lactose contents in chhana from Barbari milk. 1-2% coagulant yielded a product with higher fat, protein, lactose and minerals contents. Coagulation at 70°C produced chhana with the highest moisture content but fat, protein, lactose and mineral contents were lower. Higher temperatures (80 and 90°C) of coagulation led to lower moisture content but higher percentage of milk solids comprising fat, protein, lactose and salts. However, such a trend was always non-linear.

**Devangare *et al* (1994)** Chhana was prepared from 100:0, 75:25, 50:50, 25:75 and 0:100 mixtures of cow and goat whole milk using 1% citric acid for coagulation, and made into sandesh by kneading 250 g fresh chhana with 75 g freshly powdered cane sugar and heating for 20 minute to obtain the desired consistency. As the proportion of goat milk increased, decreases were observed in the fat and TS percentage in the milk and in the yield, TS and percentage recovery of TS in the chhana. Goat milk could be used to replace up to 50% of the cow milk without significantly affecting organoleptic properties of the sandesh.

**Sharma *et al* (1995)** Chhana, made from Jamnapari and Barbari goat milk heated to 70, 80 or 90°C with citric, lactic or tartaric acid or sour whey coagulants (each at 1, 2 or 5% with acidity of 0.8, 1.2 and 2.0%) was subjected to sensory evaluation by a panel of judges using a 6-point scale. Jamnapari milk chhana received

a higher score for colour than Barbari milk chhana (4.99 vs. 4.34); chhana made using lactic acid (5.19) received a higher colour score than chhana made using citric acid (4.89), tartaric acid (3.83) or sour whey (4.75). Coagulants in concentrations of 2 and 1% (pH 5.42 and 5.46) at 70 and 80°C yielded chhana with the best appearance. Chhana from Jamnapari and Barbari milks had soft body (4.35 and 4.22, respectively) and was not influenced by variation in coagulants, concentrations and temperatures used in its preparation. Chhana prepared from Jamnapari milk possessed better texture than Barbari milk chhana (3.97 vs. 3.71). Lactic acid produced a granular product while other coagulants gave a smooth-textured chhana. Chhana prepared from milk of both breeds had a similar flavour score (3.70 and 3.79 for Jamnapari and Barbari milk, respectively). Citric and lactic acid caused a slightly bland flavour, while sour whey and tartaric acid produced a slightly sour taste which was more pronounced at higher concentrations of coagulants.

**Bhargava, *et al* (1992)** In an experiment involving 5 replicates, the yield and quality of chhana and rasogolla from goat milk, containing 1, 2, 3, 4, 5 and 6% fat, were studied. Chhana was prepared by coagulating milk at pH 5.4 and 80°C using 0.5% lactic acid solution. Rasogollas were prepared by cooking chhana balls in 55% sugar syrup for 25 minute. Milk with 1 and 2% fat produced with a dry surface, hard body and coarse texture. Chhana obtained from 3-6%-fat milk had a fine textured, soft body with a glossy white moist surface. Yield of chhana, TS and fat contents of chhana varied significantly with variation in fat level of milk. Yields of chhana from milks containing 1, 2, 3, 4, 5 and 6% fat were 10.7, 11.6, 13.2, 14.0, 14.4 and 15.1% of the milk taken respectively and the corresponding percentages of fat in chhana were 9.3, 17.1, 22.2, 27.5, 33.1 and 38.0. The respective percentages of TS in chhana were 39.8, 44.8, 47.0, 51.5, 55.2 and 58.7. While 3 and 4% fat milks gave round, soft, spongy rasogollas of acceptable quality, rasogollas from 1, 2 and 5% fat milks were of poor quality. Milk with 6% fat produced rasogollas with completely deteriorated texture. Yields of rasogollas from milks containing 1, 2, 3, 4 and 5% fat were 22.8, 25.4, 24.4, 28.4 and 28.4% of milk taken respectively. The differences in yields were not significant. Increasing fat level in milk >3% did not appreciably increase fat in rasogollas. Goat milk with 3-4% fat can thus be utilized.

**Jailkhani & De, (1980)** prepared acceptable quality of Chhana and sandesh from goat milk The goat milk was standardised to 4% fat, without homogenization,

and coagulated at pH 5.5 and 80° C. The mean composition of chhana and the sandesh prepared are as follows moisture, 55.3 and 25.5%; fat, 23.5 and 22.9%; protein, 17.3 and 17.0%; lactose, 2.2 and 2.5%; ash, 1.6 and 1.7%; and sucrose, 0 and 29.7%. Yield of chhana was 15.8% and mean acceptability core of sandesh prepared from it was 6.4; corresponding values for controls prepared from standardized cows' milk were 15.5% and 7.3. The goats' milk chhana had a shelf life of less than 1 day at 37 degree C and 5 days at 5 degree C.

#### **Filled milk**

**Mandal (1977)** described a procedure of chhana from filled milk and it is claimed than an acceptable quality of rasogolla can be prepared using filled milk chhana.

#### **Buffalo milk**

Buffalo milk constitutes about 60% of the total milk produced in India. Traders, however, prefer cow's milk for chhana making. Since 90% of the milk processed by the organized dairies comes from buffaloes, attempts were made to improve the quality of chhana from buffalo milk. Although cow milk is preferred for chhana-making, attempts have been made to modify the buffalo milk to produce Channa of comparable quality by adjusting the pH of coagulation, temperature of coagulation, addition of body improvers, dilution of milk before coagulation and delayed straining technique. Treatment of buffalo milk with 25% water before coagulation and use of low strength citric acid solution were found to improve the texture of Channa produced from buffalo milk. Buffalo milk however renders chhana hard, making it unfit for rasogolla preparation. Addition of sodium dihydrogen phosphate, disodium hydrogen phosphate, sodium citrate and their combinations in varying quantities ranging from 1 to 2% in buffalo milk prior to coagulation helped to produce soft product (**De and Ray, 1954; Date et al., 1958**). The treatment of buffalo milk with 0.05% sodium citrate prior to boiling, dilution with 25% water and coagulation with 1 % citric acid solution improved the quality of chhana to a considerable extent. (**Iyer, 1978**). **Jagtiani et al (1960)** calcium load in buffalo milk, but chhana obtained from treated milk did not produce satisfactory quality rasogolla. Enzyme rennin was also tried, but this failed to give any satisfactory result.

**De and Ray (1954) and Jagtiani et al (1960)** observed that cow milk Chhana was soft bodied with small grainy smooth texture and more cohesive compared to



hard-bodied granular hard texture Chhana from buffalo milk. Buffalo milk Chhana retained less moisture and lactose (53.8 and 2.57%) but higher total solids (46.31%), protein (17.10%) and ash (2.03%) compared to 56.57%, 30.6%, 43.43%, 22.37% and 1.5%, respectively in cow milk Chhana. Retention of minerals (Cu, Mg, P, Citrate, Fe and Zn) was also higher in buffalo milk Chhana. On the other hand, it had less Na, K and Cl compared to cow milk Chhana. Adulteration of milk with starch produced a gelatinous mass while the presence of colostrum in milk led to pasty texture. Both of these products were unsuitable for sweet making (Ray and De, 1953). Higher concentration of casein, more so in the micellar state, with bigger size of the micelles, harder fat due to large portion of high melting triglycerides in it and with bigger size of fat globules and higher content of calcium more so in the colloidal state in buffalo milk (Sindhu and Singhal, 1988) may be responsible for harder and less cohesive Chhana from it.

The rheological differences between cow and buffalo milk chhana were studied with the help of pitching number, penetration value, springiness, viscosity and density by Gera (1978) who pointed out that the modifications suggested by Iyer (1978) improved the body and texture of buffalo milk chhana. Gera and Rajorhia (1979) designed and developed a low cost instrument for measuring the differences in the springiness of chhana from cow and buffalo milk.

Kundu and De (1972) advocated that homogenization of buffalo milk at 176 kg/cm<sup>2</sup> would improve the softness of chhana. Subsequently Kanawjia (1975) and Gajendran (1976) reported that a homogenization pressure of 140 kg/cm<sup>2</sup> should be adequate to improve the body and texture of buffalo milk chhana. On the contrary, Iyer (1978), Soni *et al.* (1980) and Ahmed *et al.* (1982) did not observe any beneficial effects of homogenization of buffalo milk for chhana making.

#### Soya milk

Chakrabarti & Gangopadhyay (1990) successfully prepared Soy-rasogolla from soy-chhana using 2% calcium lactate as coagulant at coagulation temperature of 85° C. The product resembled the market Karapak rasogolla made from milk. Use of rose flavour had a significant effect on the reduction of beany flavour of soybean.

Mandal *et al.* (1996) Chhana made from soya milk (SM), cow milk (CM), buffalo milk (BM) and 2:1, 1:1 and 1:2 blends of SM with CM or BM, was used to prepare sandesh with 80°C as cooking temperature.

Skim milk chhana was unsuitable for preparation of sandesh mainly due to its unacceptable soyabean flavour but acceptable products were obtained using chhana made from SM blends, particularly 1:1 SM: BM. Sandesh prepared from 1:1 SM: BM was of acceptable quality; it had soft body, very smooth texture and rich appearance, but had perceptible soyabean flavour, and its average composition was 73.6% TS, 14.7% fat, 23.4% protein, 34.1% total carbohydrate and 1.4% ash. Optimum level of sugar addition was 30% by weight of chhana.

**Katara & Bhargava (1992)** prepared Chhana from 80:20 and 70:30 blends of standardized buffalo milks (2 and 3% fat) with soya milk and control cow milk (3.5% fat). The 80:20 buffalo milk (3% fat): Soya milk blend most closely resembled cow milk but all blends had less total fat and carbohydrate, and more protein than cow milk. Mean yields of fresh and moisture-free chhana made from the blends did not differ significantly from those of controls, but experimental chhana had higher ( $P<0.01$ ) moisture and total protein, and lower ( $P<0.01$ ) fat contents. Colour/appearance of experimental chhana was inferior to that of controls, body/texture scores were slightly lower and the chhana had a slight beany flavour; springiness and penetration values were also lower. Chhana prepared from 2%fat buffalo milk with 20% Soya milk had sensory characteristics most closely resembling those of the control chhana. It is concluded that either blend of 2%fat buffalo milk or the 80:20 blend of 3%-fat buffalo milk with Soya milk can be used to produce chhana of acceptable quality.

#### **Use of concentrated and dried milk**

The possibility of utilizing vacuum concentrated milk and whole milk powder in the manufacture of good quality chhana suitable for rasogolla making has been established. Chhana was prepared for normal milk and concentrated milk with varying total solids. In case of concentrated milk, the coagulation of milk solids was incomplete and the losses of whey solids were high. Retention of desired moisture level in chhana was achieved at coagulation temperature of 70° C. The rheological properties and sensory scores were also favourable. Good chhana samples from cow concentrated milk were obtained at pH 5.4 and in case of buffalo milk at pH 5.1. The effect of coagulant was not found to be very significant as far as the chemical composition of chhana is concerned.

## **b. Quality of milk**

**De (1980)** recommended that minimum fat content of 4% in cow milk and 5% in buffalo milk was essential to obtain chhana with satisfactory body and texture. Crossbred cow's milk having 4% fat results in best quality chhana for rasogolla making (**Rao, 1971**). Lower than 4% fat leads to hard body and coarse texture in chhana while higher fat level results in the greasy surface. Acidic milk produces chhana with sour smell and bitter taste, rendering it unfit for sweet preparation (**De, 1980**).

**Abraham (1977)** has recommended that sour milk ranging from 0.25 to 0.28% lactic acidity could be utilized for the preparation of good quality chhana by adding 0.2% sodium citrate followed by thorough washing of the coagulum. Adulteration of milk with starch tends to produce a gelatinous, mass, and presence of colostrum in milk leads to a pasty texture in chhana, both of which are unsuitable for sweets making (**Ray and De, 1953**). Homogenization of cow milk was recommended to bring about minor improvement in the recovery of milk solids without affecting the quality of chhana (**Jagtap and Shukla, 1973**).

## **c. Condition of Coagulation**

This includes the factors like type of coagulant, strength and amount of coagulant solution, temperature and pH of coagulation and speed of stirring during coagulation.

## **d. Type of Coagulant**

Generally organic acids like citric, lactic or their salts (calcium lactate), lemon juice and sour whey are employed as coagulants. **Ray and De (1953)** and **De and Ray (1954)** reported that lactic acid tends to produce chhana with granular texture (fit for rasogolla making), while citric acid results in pasty texture (suitable for sandesh preparation). On the contrary, **Rao (1971)**, **Gajendran (1976)** and **Singh and Ray (1977)** proposed that satisfactory quality rasogolla can also be made from citric acid coagulation. Sour whey with about 0.9% lactic acid may be used for chhana making successfully (**Mahanta, 1964**). **Srinivasan and Anantakrisnan (1964)**, **Gera (1978)** and **Aneja et al. (1982)** have also suggested the use of sour whey for producing soft quality chhana suitable for rasogolla making.

Yield of chhana did not vary significantly with different coagulants. Lactic, tartaric and citric acids produced chhana with soft body; lemon juice resulted in slightly hard body. On the basis of total sensory scores, lactic acid produced best results (Joshi *et. al.*, 1991).

The use of calcium lactate as a coagulant for chhana making at home is very common in West Bengal (Chakravarti, 1982). Calcium lactate produces chhana with bright white colour, soft body, smooth texture and pleasant flavour. This chhana can be used for sandesh preparation (Sen and De, 1984).

Anon (1993) described the methods and equipment for manufacture of chhana and sondesh (sweetmeats). Chhana is prepared by adding sour whey to boiled milk (82° C, pH 5.4); after coagulation, whey is removed and the chhanna is filtered. To prepare sondesh, sugar and chhanna are mixed and kneaded; the mixture is heated until sticky and flavourings (cardamom) are added. The mixture is spread onto a tray and allowed to cool and set before cutting or moulding into desired sizes and shapes.

Sen (1985) prepared chhana using 2, 4, 6 or 8% calcium lactate as coagulant at a mean temperature of 90 degree C. The yield and moisture % respectively of the chhana decreased with increasing lactate concentration from 26.6 and 68.66% (with 2% lactate) to 22.6 and 60.4% (with 8% lactate), whilst % recovery of milk solids in the chhana increased correspondingly from 64.92 to 69.61%. The temperature change that occurred during chhana production was from 100 degree to 80 degree C and from 95 degree to 85 degree C in that coagulated with 2 and 8% lactate, respectively. Chhana coagulated with 2% lactate received lower sensory scores than that prepared with higher lactate concentration and was unsuitable for sandesh production. 6% lactate gave the most acceptable chhana, and is recommended for chhana and sandesh production.

Singh & Ray, (1977) prepared Rasogolla and sandesh (sweet meat preparations) from chhana (coagulated milk solids) using (i) aged whey, (ii) citric acid and (iii) lactic acid as coagulants. Sweet meats prepared by (i) and (ii) were acceptable to the panel. Compositions (protein, fat, sugar and TS) of the rasogolla and sandesh prepared using (i)-(iii) are given in tables. Both products from market were poor in fat and protein but rich in TS and sugar.

### **e. Strength of Coagulant**

Low acid strength (0.5%) results in very soft body and smooth texture suitable for rasogolla but unsuitable for sandesh making (De and Ray, 1954; Soni *et al.*, 1980) while high acid strength (8%) results in hard body and less smooth texture, suitable for sandesh making but not for rasogolla. The optimum strength of coagulant solution should be between 1 and 2% citric or lactic acid to produce good quality chhana suitable for making both kinds of sweetmeats (De and Ray, 1954; Iyer, 1978). Some workers have recommended that good quality chhana from buffalo milk can be prepared from 1% citric acid solution (Kundu and De, 1972; Ahmed *et al.*, 1981). A satisfactory quality of chhana from buffalo milk was also prepared with 0.5% lactic acid coagulant (Soni *et al.*, 1980). Acidity of sour whey is also an important factor in the coagulation process. Sour whey of 0.9% lactic acidity was found useful for chhana making by Mahanta (1964), whereas Singh and Ray (1977) obtained good quality chhana from sour whey containing 1.6% lactic acid. Recently, Sen (1985) noted that 6% calcium lactate solution produces most satisfactory quality.

### **f. Amount of Coagulant**

Usually, 2-2.5 g of citric or lactic acid per kg of fresh milk is needed for coagulation. Nearly 3.5 g of citric acid per kg of cow milk was required for producing best quality chhana for rasogolla making (Rao, 1971). Later, Gajendran (1976) used about 1.5g of citric acid per kg of buffalo milk. Soni *et al.* (1980) found that only 1.25 g of lactic acid per lit of buffalo milk is required to produce good quality chhana for rasogolla. Iyer (1978) calculated that about 2.5-3.4 g of citric acid or 3.0-3.9 g of lactic acid per lit of milk was necessary to achieve complete coagulation. The exact quantity of coagulant is dependent on the type of milk. It is not clear as to why Singh and Ray (1977) used 10.7g of citric acid and 9.6g of lactic acid per lit of cow milk for coagulation. These figures are extremely high as compared with other reported values. They further found that about 589 ml of sour whey is needed to produce suitable quality chhana. Of late, Sen (1986) reported that the amount of calcium lactate needed for complete coagulation ranged from 6 to 12 g per kg of milk depending on the coagulation temperature.

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### **g. Temperature of Coagulation**

Chhana, of satisfactory quality from cow milk can be made, when milk is coagulated at about 82° C, and the coagulation process completed in 0.5-1.0 min (**De and Ray, 1954**) by Iyer (1978) at a coagulation temperature of 70° C. The optimum coagulation temperature for buffalo milk is 70° C (**Kundu and De, 1972; Gajendran 1976; Iyer, 1978; Soni et al., 1980; Ahmed et al., 1981**). The amount of coagulant required for completing the coagulation of milk is increased with the lowering of coagulation temperature (**Singh and Ray, 1977; Soni et al., 1980; Sen, 1986**). As the coagulation temperature decreases, the moisture retention in chhana increases leading to its softer body and smoother texture (**De and Ray, 1954; Soni et al., 1980 Sen, 1986**). The temperatures of coagulation exert a significant influence on physico-chemical attributes. Coagulation of milk at 70° C produced a very soft Chhana but higher temperature produced grainy texture and increased the hardness, whereas coagulation at 35° C produced highly sticky product. Citric acid as coagulant yielded more cohesive Chhana and lesser losses of milk solids in whey. The effect of addition of 0.05% sodium citrate to buffalo milk before boiling, dilution of milk with 25-50% water, use of 1% citric acid instead of 2%, addition of 40 to 60% cow skim milk, acidification of milk before coagulation, delayed straining and homogenization of milk were studied and it was found that the first three treatments had the beneficial effect, while the later four treatments had the adverse effect on the texture of Chhana. **Soni et al (1980)** studied the effect of method of straining, temperature and pH of coagulation on physico-chemical properties of buffalo milk Chhana and found that delayed straining of previously boiled milk produced soft and smooth Chhana suitable for Rasogolla production. Boiling of milk prior to coagulation was an indispensable step in production of Chhana. Optimum temperature and pH were 70° C and 5.7, respectively. Coagulation above 70° C gave a hard and granular Chhana unsuitable for Rasogolla-making. Yield of Chhana was more by delayed straining, irrespective of pH and temperature of coagulation. Proteolysis of buffalo milk by trypsin prior to coagulation produced a Chhana with very soft and smooth body having minute sized micelles. Addition of 0.3% sodium citrate to buffalo milk was found to be effective in producing Chhana similar to cow milk Chhana in springiness and producing a good quality Rasogolla (**Rao, 1986**).

Buffalo milk Chhana produced with the addition of 0.3% sodium citrate had lower acidity and higher pH compared to cow milk Chhana.

**Choudhary et al, (1998)** studied effects of heating and cooling processes on recovery of milk solids from chhana produced from cows' and buffalo's milks. Whey protein denaturation was used as an indicator for heat treatment. When the whey protein denaturation was varied from 0.485 to 6.642, recovery of milk solids ranged from 0.512 to 0.649 kg/kg for cows' milk and 0.535 to 0.649 kg/kg for buffaloes' milk. Recovery of milk solids increased with lower whey protein denaturation during heating and cooling, prior to acidification. For low levels of whey protein denaturation, it was necessary for milk to be subjected to a temp. of greater than 75 degree C for a short duration. A fast cooling rate was found to be more desirable than a fast heating rate.

**Sen (1986)** prepared Chhana from whole milk at coagulation temperature (CT) of 95, 90, 85, 80 or 75 degree C and the amount of calcium lactate (4% solution) required for coagulation increased with decreased temperature from 150 to 296 ml/kg milk; yield and moisture content also increased from 21.2 to 25.4% and from 62.4 to 68.6%, respectively. Recovery of milk solids in chhana was maximum at CT of 80 and 85 degree C. Whiteness, smoothness and softness increased with decreased temperature and chhana made at CT less than 80 degree C was unsuitable for sandesh manufacture; flavour was not affected by CT. Chhana made using calcium lactate had higher calcium and moisture than standard chhana (made using citric acid).

#### **h. pH / Acidity of Milk**

The optimum pH for chhana making from cow and buffalo milk is 5.4 and 5.7 respectively. The pH of coagulation principally regulates the moisture content and the body and texture which are best obtained at the above pH (**De and Ray, 1954**); **Singh and Ray, 1977**; **Soni et al., 1980**). **Iyer (1978)** however, found that most suitable pH for coagulating all types of fresh milk is 5.1. Very recently, **Sen and Rajorhia (1986)** noted an optimum pH of 5.85 for cow milk when calcium lactate was used as coagulant. **Abraham (1977)** observed that acidic milk with 0.25-0.28% acidity can be utilized with the addition of 0.2% sodium citrate of milk followed by thorough washing of curd after coagulation of milk. **Ray and De (1953)** and **De and Ray (1954)** found that lactic acid produced grainy Chhana suitable for Sandesh-making,



while citric acid produced pasty Chhana suitable for Rasogolla-making. Chhana produced with calcium lactate as coagulant was bright white in colour, soft in body and smooth in texture and had pleasant flavour and can be used for the preparation of Sandesh (Sen and De, 1984). Low acid strength produced a Chhana which was hard and less smooth suitable for Sandesh but unsuitable for Rasogolla (De and Ray, 1954; Soni *et al*, 1980).

Adhikari *et al.*, (1992) investigated the effects of pH of coagulation (5.2, 5.4 or 5.6) and washing of curds in demineralized water (0-3 times) on the mineral composition and textural properties of chhana manufactured from cows' milk (4% fat) or buffaloes' milk (7.8% fat). A decrease in the mineral content of the whey fraction was observed with decrease in coagulation pH; % of soluble minerals increased in both buffaloes' and cows' milk chhana with decrease in pH. Washing curds resulted in a 15-90% loss of ionic or soluble minerals and 15-35% loss of minerals present in a colloidal form. Instron textural parameters, apart from cohesiveness, were significantly correlated with mineral content of chhana. Buffaloes' milk chhana, containing a higher proportion of all major minerals, had higher values for hardness, springiness, gumminess and chewiness than that of cows' milk. Results suggest that a reduction in coagulation pH and subsequent washing of curds results in decreased mineral retention in buffaloes' milk chhana and a softer, smoother and less chewy product. Such chhana may be used as a substitute for cows' milk chhana in the manufacture of chhana-based Indian dairy products.

#### **i. Speed of Stirring**

Higher speed of stirring during coagulation reduces the moisture content in chhana and increases its hardness, whereas with lower speed the reverse holds true. Slow stirring (40-20 rpm) is preferred to avoid foam formation (Ray and De, 1953; De and Ray, 1954).

#### **j. Method of Straining**

Delayed straining produces a comparatively soft and smooth texture chhana than immediate straining. Delayed straining gives a higher proportion of moisture, yield, recovery of milk solids and lower hardness value in chhana than immediate straining. Chhana made by delayed straining is useful for rasogolla making

(Kundu and De, 1972). Many other workers have also suggested delayed straining process especially for buffalo milk chhana production (Iyer, 1978; Soni *et al.*, 1980; Ahmed *et al.*, 1981).

## **New Approaches to Chhana Manufacture**

### **Casein process for Chhana making.**

The batch method of chhana-making meets the need of small enterprises and cannot be exploited for commercial production. A strong possibility is suggested for adopting the continuous casein equipment for large-scale production with certain modifications. The modification are (a) intake of milk at 70° C instead of 35° C; (b) strength of coagulant not to exceed 2%; (c) automated mixing of coagulant and milk to obtain a pH of 5.1; (d) adequate residence time to effect co-operation of casein and whey proteins together with fat; (e) mechanical removal of whey using a basket centrifuge or provision of additional vibrating screen as chhana drains too slowly; (f) washing of coagulum once with potable water followed by pressing to retain about 60% moisture in the finished product; and (g) arrangement for bulk packaging to synchronize with product delivery through a suitably developed device.

Sharma (1998) made the use of ultrafiltration (UF) in the manufacture of chhana and chakka (the intermediate product obtained by draining of dahi during manufacture of shrikhand). During traditional chhana /chakka manufacture, whey proteins of high biological value drain out along with the whey. These proteins should be retained by the application of UF. Processes involved in the manufacture of UF chhana and UF shrikhand, and sensory qualities of the final product are described. It is concluded that good quality chhana and shrikhand are produced using UF technology. Savings in milk use added to the recovery of whey protein highlights the feasibility of using UF technology on an industrial scale.

Sachdeva & Reuter (1991) successfully used ultrafiltration in the manufacture of chhana. The ultrafiltration behaviour of pasteurized whole milk vs. severely heated whole milk, as regards the flux, energy requirement for concentration and retention coefficient was studied. Chhana was manufactured from ultrafiltrated retentates obtained by ultrafiltration of pasteurized whole milk and that of severely heated whole milk. The process was standardized with respect to the heat treatment, concentration of coagulant, and temperature and pH of coagulation.

An increase of 31.4% in the yield of chhana on product basis and of 16.4% on DM basis was achieved. Only 4.35 kg of milk was used to produce 1-kg chhana by the ultrafiltration method against 5.7 kg of milk by the conventional method. The process offers access to easy automation and control ensuring uniformity of production on a large scale.

**Sharma & Reuter (1991).** successfully prepared Chhana (43% TS) using skim-milk ultrafiltered-diafiltered retentate and plastic cream [cone cream with a high fat content]. Severely heated skim milk (95 degree C/5 min) was ultrafiltered to 26.73% TS in a Ceraver P-19-40 ultrafiltration module at 50 plus/minus 2 degree C and 4 bar trans membrane pressure with an average flux of 49.63 l/h/m<sup>2</sup>. The retentate was diafiltered with equal amount of water in order to reduce lactose and increase the protein content in the dry matter. After diafiltration the retentate comprised 23.57% TS, 17.5% protein and 1.0% lactose. The retentate was the stock material for chhana mixture and stored at -35 degree C until required. For the preparation of chhana, the retentate was mixed with plastic cream to a protein/fat ratio of 0.722. The mixture was heated to 85-90 degree C/5 minute and coagulated with dilute lactic acid to develop the characteristic grains. The granular mass was pressed to remove free moisture, yielding chhana. The new process yielded 18.68% extra chhana as compared to the traditional method. The sensory evaluation of the product in relation to the traditional product showed no significant difference in flavour, body and texture or appearance. Higher yield, easy automation, and flexibility of operation are the inherent advantages of this new ultrafiltration process. This process had the scope for large-scale production of chhana by the Indian dairy industry.

### **Mechanized Process**

**Aneja et al. (1977)** designed and developed a prototype continuous chhana making plant capable of producing 40-kg product/hr. Standardized milk is pumped to a vertical insulated tank at the rate of 250 litre/hr. culinary steam at 1 kg/cm<sup>2</sup> is injected into milk through a ventury system. Sour whey is introduced at this juncture and mixture allowed to flow into a chamber where coagulation is completed. Coagulated mass is then allowed to flow through a double-jacketed tube with tap water circulation. Chhana is drained in two stages, firstly over an inclined sieve jacket and then over a slow moving conveyor belt.

Short shelf life is the major problem encountered with the product.

This unit was subsequently improved by **Aneja *et al.*, (1982)**. **Kishore and Aneja (1981)** developed a continuous mechanical strainer for drainage of chhana whey. The major components of the equipment are: (1) balance tank, (2) injection chamber, (3) holding coils, (4) cooling chamber, and (5) strainer. The standardized cow milk is pumped from the balance tank at the rate of 250 litres/hr. Simultaneously, its temperature is raised to 90° C by direct injection of culinary steam at 1 kg/cm<sup>2</sup> gauge pressure and at the rate of 65 kg/hr in the injection chamber. Thereafter, the milk is brought in contact with sour whey, the quantity being regulated in proportion to the rate of milk flow. The mixture of milk and whey is circulated through 8 meter x 10mm holding chamber for achieving complete coagulation. The coagulated product along with whey is then pumped into a double-jacketed cooling tank where it is cooled to near room temperature. Finally, the product is directed inclined sieve, where it is drained thoroughly. Chhana with 60-65% moisture is discharge through the outlet and collected in the containers. Drained whey is transferred to a holding tank for natural souring for subsequent use.

**Tiwari & Sukumar, (1976)** studied the three drying processes, at three milk fat levels and five types of chhana slurry in experiments undertaken to standardize an industrial method, using cows' milk, for production of dried chhana for use in the preparation of sandesh. Optimum results were obtained from milk with 4% fat content, using the spray-drying process and slurry prepared from experimental chhana (milk is boiled, cooled to 80 plus/minus 5 degree C, 0.02% sodium citrate emulsifier is added for 2 plus/minus 0.5 h and coagulated until whey is clear. the chhana is collected, weighed, broken up, water added to give 19-21% TS, and blended to a smooth slurry). The product prepared in this way had an average composition of 3.5% moisture, 41.6% fat, 46.3% protein, 4.2% lactose and 4.4% ash.

## **Yield**

In general the outturn of chhana increases with lowering the strength of coagulant solution, coagulation temperature and speed of stirring during coagulation (**De and Ray, 1954; Ahmed *et al.*, 1981; Sen, 1985; Sen, 1986**). The yield of chhana from buffalo milk is higher than cow milk (**Ray and De, 1953**). They also reported the average yield of 16.4% from cow milk and 22.5% from buffalo milk.

The moisture content in chhana prepared by them was too low i.e. 53.9 and 48.9% respectively. **Iyer (1978)** obtained 20% yield from cow milk and 25.8% from buffalo milk. **Singh and Ray (1977)** obtained 20% yield from cow milk. Studies of **Ahmed et al. (1981)** revealed that at 60° C coagulation temperature, the yield from buffalo milk was 19.6%, however, **(Kundu and De, 1972)**, but **Iyer (1978)** described that the maximum yield at 70° C is due to the retention of higher amount of moisture and not because of greater recovery of milk solids in chhana. In fact, the percent recovery of milk solids decreased in chhana coagulated at 70° C. Further, lowering of coagulation temperature produced an adverse effect on the yield of chhana **(Kundu and De, 1972); Iyer, 1978)**. Higher yield of chhana was obtained when sour whey was used as a coagulant than those from citric acid or lactate acid **(De and Ray, 1954; Singh and Ray, 1977; Srinivasan and Anantakrishnan, 1964)**. Chhana made from calcium lactate showed always-higher yield than citric acid. This was mainly due to higher moisture retention capacity in calcium lactate chhana **(Sen and De, 1984; Sen, 1986)**. Homogenization of milk and delayed straining increased both yield and percent recovery of milk solids in buffalo milk chhana **(Kundu and De, 1972)**, but **Iyer (1978)** has contradicted this finding.

### **Microbiological Quality**

The microbiological studies are carried out to assess the standard cleanliness during production, packaging, transportation, and storage and for ascertaining the shelf life of chhana. Market samples were heavily contaminated with a variety of organisms. The average initial number of viable organism per g of chhana was about 16000 which increased to 110 million after 48 hrs **(Anonymous, 1955-56)**. The initial mould count was 260 per g rising to 3,85,000 per g at the end of 4 hr. A few studies on the type of organism present in chhana samples revealed the presence of micrococcus spore and nonspore forming rods contributing 45.3 and 21% of total population respectively. The most common type of moulds contaminating chhana gillus, mucor, rhizopus, fusarium and paecilomyce **(Anonymous, 1955-56)**.

**Singh and Mukhopadaya (1975)** showed wide variations in the total plate ( $0.9 \times 10^6$ ), coliform ( $0.139 \times 10^5$ ), staphylococcus ( $0.22 \times 10^4$ ) counts per g of chhana sample collected from Ka lyani and Suburbs demonstrating that the quality of market chhana samples was unsatisfactory and highly contaminated.

**Kumar and Srinivasan (1982b)** examined three kinds of fresh chhana samples viz. cows milk and market samples for total plate, acid producing, proteolytic, chromogenic, aerobic spore forming bacilli and yeast and mould counts. The market samples carried higher counts in all cases as compared with cow and buffalo chhana except for yeast and mould counts. Cow milk chhana showed high counts in all the tests except for lipolytic, yeast and mould counts. High bacterial counts in chhana are expected due to its high moisture content and handling under unhygienic environment.

### **Shelf life & Packaging**

Chhana is a high moisture product. It is common knowledge that it does not keep longer than a day at room temperature. **De and Ray (1953)** improved the shelf life of chhana to about 3 and 12 days at low temperature storage viz. 24° C and 7° C respectively. **Srinivasan and Anantakrishnan (1964)** observed that freshly made chhana wrapped in vegetable parchment paper could be preserved in good condition for 3 - 4 days at 21° - 27° C and for about 10 days in a refrigerator. The shelf-life of laboratory samples of chhana ranged from 24 to 48 hr while for market chhana it was only 6 to 8 hr in summer and 16 to 20 hr in winter (**Anonymous, 1955-56**). Although the addition of 0.5% sodium benzoate or 0.2% sodium propionate was effective to check the growth of microorganisms, but these preservatives imparted disagreeable odour considerably. Treatment of butter paper with sodium propionate solution prior to packaging increased the shelf life of chhana. A thin coating of 30% sugar solution on the surface of chhana could suppress the mould growth, to some extent (**Anonymous, 1955-56**).

**Kumar and Srinivasan (1983)** recommended the use of tin containers for storage of chhana at 37°±. 5° C. At low temperature, tin container was not very effective. The laminates of moisture proof heat sealable, transparent cellulose film, and low-density polythylene and poster at 4° - 5° C.

**Kulkarni et al. (1984)** observed that 10 min steaming and sterilization of chhana at 1.05 kg/15 min in the presence of 1% lactic acid solution improved its shelf-life upto 6 and 8 days respectively at 30°±1° C. Chhana could be preserved for 4 days at the same temperature by treating it with 2% potassium sorbate and 2% lactic acid solution.

The steaming, however, resulted into hardening of body and the sterilization caused browning and development of cooked flavour. Chhana preserved by these methods may be useful for sandesh preparation. Recently, **Yadav *et al.* (1985)** added to milk sodium benzoate and potassium metabisulphite at 0.1% and 0.2% solution of these preservatives at 30° C, the samples showed the signs of deterioration after 2 days of storage.

**Goyal (1992)** studied the influence of packaging and types of Chhana on the water vapour transmission rate of flexible packages and found out that, since chhana has a high moisture content; quality of the stored product is greatly influenced by the moisture barrier properties of the packaging material. The water vapour transmission rates (WVTR) of 3 types of flexible packaging (60 g/m<sup>2</sup> poster paper/0.02 mm aluminium foil/150 gauge polyethylene (P1), 60 g/m<sup>2</sup> poster paper/0.009 mm aluminium foil/150 gauge polyethylene (P2), Cellophane/150 gauge polyethylene (P3)) were determined after storage of chhana for 0-3 days (37 plus/minus 0.5 degree C, RH 60 plus/minus 5%) or 0-30 days (4-5 degree C, RH 90 plus/minus 5%). WVTR increased with increase in storage temp. The WVTR of all 3 packaging materials increased significantly (P less than 0.01) with duration of storage; the increase was greatest in P1 and least in P3. The type of chhana packaged (cows' milk, buffaloes' milk, market milk) also had a significant effect (P less than 0.05) on the WVTR of the packaging materials.

**Goyal (1991)** studied the effect of 3 different types of flexible packaging materials, i.e. poster paper/aluminium (Al) foil/LDPE (55/60 g/m<sup>2</sup>, 0.02 mm and 150 gauge) - P1; poster paper/Al foil/PLDPE (55/60 g/m<sup>2</sup>, 0.009 mm and 150 gauge) -P2; MST cellulose film/LDPE (30 g/m<sup>2</sup> and 150 gauge) - P3; and also tin cans - P4, on chemical quality of 3 types of chhana. Chhana prepared in the laboratory from cows' and buffaloes' milk and purchased from the market was stored at 4-5 degree C and 100% RH for various time intervals. For the flexible packages, chhana samples packaged in P1 showed min. chemical changes during storage, thus proving P1 the best packaging, followed by the samples packed in P2 and P3, in descending order. The 4 types of packages, the 3 types of chhana, and the intervals of storage [0-30 days] each individually influenced the chemical quality of chhana. During storage, moisture and lactose contents decreased, while titratable acidity, peroxide value, and

free fatty acid and tyrosine contents increased.

**Kulkarni *et al.*, (1984)** made attempts to increase the keeping quality (KQ) of chhana to greater than 2 days at 30 degree C. In general, storage in water, citric or lactic acid whey, or 1 or 2% citric acid failed to increase KQ, as did steaming of the chhana for 10 min after 8 h storage in water. Storage in 1 or 2% lactic acid, or in 1 or 2% citric acid + steaming for 10 min, increased the KQ to 3 days. Storage in 1 or 2% potassium sorbate, particularly when combined with steaming increased the KQ, but off-flavours developed during subsequent storage. '3 successive steamings in water, whey or acid increased KQ, the most effective treatment being steaming 3x in 1% lactic acid, which increased KQ to 5 days. Steaming tended to make the chhana hard, brittle and paneer-like; it was suitable for use in making sandesh but not rasogolla.

**Goyal (1994)** The influence of packages storing of Chhana on the bursting strength of flexible packages revealed that as the duration of storage progressed, the burst value decreased. The conditions of storage in terms of temperature and relative humidity of the packaged product had definite influence on the changes in burst value; the low temperature storage coupled with higher humidity resulted in more decrease in bursting strength of the packages. The type of chhana samples, duration of storage, type of packing materials, and the interaction packaging x period of storage significantly ( $P < 0.01$ ) affected the bursting strength of the flexible packages

Only few studies have been conducted on preservation of chhana. Shelf life of the product, so packaged was 2, 3 and 12 days at about 38° C, 24° C and 7° C, respectively (**De and Ray, 1954**). Vegetable parchment has been employed for packaging of chhana but with limited success.

### **Nutritive Value**

Chhana retains about 90% of fat and proteins, 50% ash and 10% lactose of the original milk. The energy value of cow chhana ranges from 2866 to 3748 calories per kg. Chhana also retains appreciable proportion of fat-soluble vitamins like A and D (**Ray and De, 1953**). **Mani *et al.*, (1955)** observed that the average calcium, phosphorous, vitamins A, B1, B2 and C contents per 100g of chhana samples were 208 mg, 138 mg, 366 IU, 73 mg, 15 mg and 2.8 mg respectively. Because of possible losses in whey, chhana is a poor source of B vitamins, lactose, ascorbic acid and



vitamin A contents, when compared with milk, dahi, khoa and kheer. Chhana contained practically no nicotinic acid. They calculated that the loss of ascorbic acid during chhana making was about 57% as compared with the figure of boiled milk. **Balasubramanian et al (1955)** examined the average biological value and digestibility co-efficients of chhana to be 67 and 97 respectively but they could not estimate its protein efficiency ratio because the consumption pattern of basal diet mixed with chhana by the albino rats was very low. The average consumption of diet hardly crossed 5 g/day and the weight of some animals declined below their original weight, therefore, no conclusion could be drawn.

**Lily et al. (1955a)** observed that the female rats fed on chhana diet showed highest cases of sterility in the first generation itself. This is possibly due to deficiency of B vitamins and vitamin A. however, the findings need further investigation to be conclusive. Subsequently, supplementation of poor rice diet with chhana helped to improve the growth rate two times or more than when fed with the basal diet alone (**Lily et al., 1955b**). The animals fed with supplementary diet had remarkably better reproduction and lactating capacity than those kept solely on basal diet. Chhana is concentrated form of proteins and fat. According to **Rao et al. (1979)**, the BV of chhana was 88, digestibility coefficient 92, PER value 3.1 (casein 2.8), NPU 71.5 (casein 83.5) and NPR 5.25 (casein 4.55). Superior nutritional quality of chhana compared to casein may be attributed to the association of whey proteins, which complex with casein during the heating of milk in the manufacturing process.

### **Protien & Flavour Chemistry**

**Soni et al., (1980)** observed a few slow moving protein bands in the starch gel electrophorogram when chhana samples were prepared at pH 5.3 and 5.5. These components were missing when the chhana samples were isolated at pH 5.7. The SDS polyacrylamide gel electrophoresis revealed that some low molecular weight components are released from buffalo milk proteins during boiling.

**Kumar and Srinivasan (1984)** identified the flavour producing volatile carbonyl compounds by GLC technique. Amongst the 9 identified carbonyls in chhana samples, octan-2-one showed the most predominant peak. Other carbonyls detected were formaldehyde, acetaldehyde, acetone, butyraldehyde, pentan-2-one, heptan-2-one and nonan-2-one. Appreciable differences in the carbonyl compounds in chhana samples prepared from cow, buffalo and market samples were noted.

## Rheological Properties

Type of milk (cow, buffalo and mix) and method of manufacture also influenced the sensory and Instron parameters of Chhana (Desai *et al*, 1992b). Delayed drainage of whey produced a product with higher moisture and lower calcium. This Chhana was smooth, softer and stickier but less chewy and more acceptable from overall quality point of view. Buffalo milk Chhana was generally harder, chewier; less smooth and less sticky compared with cow milk Chhana. Mixed milk Chhana was intermediate of the two. Adhikari *et al* (1992) observed that kneading of Chhana caused a significant decrease in hardness, cohesiveness, springiness gumminess and chewiness but a considerable increase in adhesiveness. Boghra (1988) studied the changes in Chhana during storage at  $<10^{\circ}\text{C}$  for 30 days and observed a considerable increase in free fatty acids, peroxide value, tyrosine content, and acidity but a decrease in pH during storage.

Desai *et al*, (1992) studied the texture of Chhana from different market suppliers and found that texture is important in determining its use in the manufacture of sweetmeats. Variability in the texture of chhana from different market suppliers was evaluated using the Instron Universal Testing Machine and a sensory panel. Instron hardness, cohesiveness, gumminess and chewiness varied significantly in chhana samples from different suppliers. Significant variations were also noted in firmness, crumbliness, chewiness and smoothness as judged by sensory panel. Chhana which was fairly smooth but sticky, and low in firmness, elasticity, crumbliness and chewiness was sensorily most acceptable. Significant variations were observed in the moisture content ( $P \leq 0.05$ ) and pH ( $P \leq 0.01$ ) of chhana from different suppliers; variations in textural characteristics were related to some extent to variations in pH and to a lesser extent to variations in moisture content.

Desai *et al*, (1991) Chhana physically resembles ricotta cheese, and is a soft, semi-solid product with a smooth, close knit, velvety texture. Textural characteristics of chhana prepared from cows', buffaloes' and mixed milks by different methods were evaluated by instrumental and sensory methods. Instron texture profile parameters and sensory texture descriptors varied significantly between products prepared by the different methods. Delayed draining of whey and other processes yielding a product with high moisture content and lower Ca content resulted in a softer, smoother and

Stickier, but less chewy chhana; this was more acceptable in terms of overall texture quality. Mixed milk product showed intermediate values for the parameters tested; buffaloes' milk chhana was harder, more chewy, less smooth and less sticky compared to cows' milk chhana.

**Gupta *et al.* (1993)** studied the relationship between chemical composition and textural properties in laboratory-made khoa, paneer and chhana samples, and in market samples of normal and sponge rasogolla. Overall textural quality was significantly correlated with moisture, fat, protein and Ca contents ( $r = 0.51, 0.43, 0.59$  and  $0.58$  respectively, all  $P < 0.01$ ) in chhana and with fat content ( $r = 0.35$ ,  $P < 0.05$ ) in paneer. Correlations between compositional characteristics and texture parameters were generally poor in Rasogolla.

### **Economics of Manufacture**

**Chand (1994)** conducted the study on 60 indigenous milk product manufacturing units in the Ganga Nagar district of Rajasthan, India, during 1991, using a multi-stage stratified random sampling technique. The study revealed that on average an investment of Rs 4.58 lakhs was required to set up a manufacturing unit to produce a wide variety of sweets using indigenous technology. The investment varied from Rs 2.30 lakhs on a small unit to Rs 0.8 lakhs on a large unit. The study further revealed that the cost of production of Rasogolla, Cham-Cham and Sandwich that were produced by both large and small units was Rs 15.30, 15.40 and 17.83 respectively. The cost of production for Rasbhari, Zooli, Rasmalai, Rasmadhuri, Raj bhog and Sandesh which were produced by large units for the affluent members of the society was Rs 14.80, 27.82, 25.08, 18.61, 17.46 and 34.23 respectively. The percentage profit over cost in the former category of products ranged from 52 to 70%, whereas the profit margin in the products produced exclusively by the large units varied from 43 to 110%.

### **Various Products from Chhana**

**Adhikara *et al.*, (1993)** Rasogolla, a popular Indian sweetened dairy product, was made from buffalo milk chhana (a soft Cottage cheese analogue) by adding 2% wheat flour, 0.02% baking powder and flavouring. Chhana, formed into balls (12-15 mm diam.) was cooked in 60% sugar syrup for 15 min, transferred to 50% sugar syrup for 1 h and then stored overnight at 22 degree C. SEM of chhana revealed

Coalesced, compact casein micelles with fat globules cemented together and numerous small voids interspersed throughout the matrix, resembling paneer or Cottage cheese structure. As a result of cooking of chhana, fat globules ruptured and finally coalesced to large masses and voids increased markedly, producing a highly ragged and uneven matrix with carded cotton-like structure in rasogolla. Market rasogolla made from cows' milk showed thick thread-like coalesced casein micelles forming a very loose matrix with numerous large voids in between. Textural studies demonstrated significantly higher hardness and gumminess, but lower springiness and chewiness in chhana than in rasogolla. Market rasogolla had textured properties close to those of laboratory made samples. Moisture content was significantly negatively correlated with all Instron textural parameters, while protein, ash and calcium contents exhibited significant positive correlation with all textural characteristics except springiness for both chhana and rasogolla. No correlation was found with fat, lactose or sucrose contents and any of the textural parameters. Composition, texture and microstructure of both chhana and rasogolla, were found to be interrelated.

**Jindal & Grandison (1994)** studied the protein solubility, emulsifying, foaming, and gelation properties, and viscosity of solutions of chhana whey protein powders, produced by ultrafiltration and reverse osmosis followed by drying, over the pH range 2.5-9.0. Protein solubility varied from 57 to 100% and was greatest at low pH values. Chhana whey protein powders had similar emulsifying properties to commercial cheese whey protein powders of similar protein content, although the capacity to form gels when heated to 80 degree C was much lower, particularly at alkaline pH. Viscosity of chhana whey powder solutions was sensitive to pH, but was particularly high in the acidic range. Results demonstrate considerable potential for the utilization of chhana whey products in the food industry.

**Kumar *et al.*, (1992)** investigated the textural and organoleptic properties of rasogolla samples prepared from chhana. Chhana was prepared by coagulating cows' milk (0.1, 1.0, 2.0, 3.0 or 4.0% fat) with citric or lactic acid at 70, 80 or 90 degree C. Increased milk fat content was associated with a decrease in hardness, springiness, gumminess and chewiness of rasogolla and a significant increase ( $P$  less than 0.01) in cohesiveness. Rasogolla prepared from citric acid chhana had significantly ( $P$  less than 0.01) higher values for hardness, cohesiveness, springiness, gumminess and chewiness compared with lactic acid chhana.

Hardness, cohesiveness, springiness, gumminess and chewiness of rasogolla increased significantly ( $P$  less than 0.01) when temp. of coagulation was increased from 70 to 80 degree C or from 80 to 90 degree C. Organoleptic properties of rasogolla were optimal when chhana prepared from milk (3.0% fat) coagulated by 1% lactic acid solution at 70 degree C was used.

Tewari *et al.*, (1991) prepared chhana/paneer spread, by breaking chhana into small pieces, adding water and grinding into a paste in a domestic mixer. Moisture content of cow's milk and buffaloes' milk chhana spread was maintained at 62% and 64%, respectively. Salt (1-5.1%) was added during grinding; an acidifying agent was added to lower the pH of the spread to 5.1-5.0. The product had a bland taste, which was eliminated by the addition of chakka or ripened cheese. Chakka (30 g) and salt (1.0-1.5%) were added to chhana (70 g) and then mixed; addition of spices (mint, coriander, ginger and garlic) was optional. When packed in polystyrene cups and refrigerated, the product had a shelf life of approx. 8-10 days.

Tewari & Sachdeva (1991) studied the effects of moisture level, addition of emulsifier, heat treatment, homogenization, pH level, and addition of chakka and ripened cheese on the sensory quality of chhana spread. A good flavoured and spreadable chhana spread was made from cows' and buffaloes' milk chhana containing 62.5 and 63.5% moisture, respectively. The pH of the most acceptable spread was 5.0. Addition of emulsifier and heat treatment did not improve body or texture of the spread and homogenization could not be achieved. Addition of chakka (30%) or ripened Cheddar cheese (20%) further improved the sensory score.

Chhana obtained from cows' or buffaloes' milk was used to prepare an acceptable bland flavoured spread. The cows' milk spread obtained higher scores for its sensory attributes. Spread made from cows' or buffaloes' milk, standardized to a fat:SNF ratio of 1:3 was equally good in its sensory quality to that obtained from milks standardized to a fat:SNF ratio of 1:2. Lower temperature of coagulation resulted in a softer chhana and consequently better body and texture in the spread (Tewari & Sachdeva, 1991).

Dash *et al.*, (1999) analysed 10 samples of chhana podo, a chhana-based sweet, collected from the markets in Puri, Bhubaneswar and Cuttack in Orissa, India, for sensory quality and composition. Channa podo had a light brown colour, spongy texture, slightly cooked flavour and was generally acceptable. Composition

varied widely and moisture, fat, protein, sugar and mineral percentages ranged from 27 to 41, 18 to 30, 11 to 25, 15 to 30 and 0.7 to 1.5 respectively, while titratable acidity ranged from 0.18 to 0.45.

## **SANDESH**

This is channa based sweet with a somewhat firm body and a smooth texture. It is a delicacy from the eastern parts of India, and made into variety of forms and shapes. It can be layered/topped with different types of pastes, chocolate etc. Chhana is cooked with sugar on low heat in shallow vessels. The processed mass is placed into moulds to give imaginative forms and shapes. Colour and essence may be added.

Channa and sugar (30 -0 35% of channa) are mixed, kneaded together and then heated in a shallow vessel after addition of colour and flavour. The heated mass is removed directly into moulds to give the desired shape. The sweets are now ready for consumption. Alternatively, the processed mass is put into a tray, cooled and set. It can then be cut into desired shapes or moulded into required forms. It is estimated that about 80% of channa produced are converted to sandesh.

### **Type of Milk**

#### **Cow milk**

**Sen & Rajorhia (1990)** standardized the production of soft grade (Narampak) Sandesh from cows' milk. Fresh cows' milk was adjusted to 4% fat with a TS to fat ratio of 3.14,<sup>1</sup> before coagulation at 80 degree C with 2% citric acid solution followed by straining and pressing for 15 min. Chhana with 55-59% moisture was rendered to a smooth paste and divided into 2 equal portions. To half, cane sugar was added at the rate of 30% by wt. of total chhana. The mixture was cooked by raising the temp. to 75 degree C in 15 min with continuous stirring and scraping until the initial pat stage developed. The remaining chhana was added and heating continued at 60 degree C with constant stirring for 5 min to develop the characteristic cooked flavour. The mixture was cooled to 37 degree C in 10 min, hooped and later sliced into desired shapes and sizes. Addition of colorants and flavourings is optional

#### **Buffalo milk**

Sandesh is usually prepared from cow milk. First of all, the most popular Sandesh varieties were collected from Calcutta and Delhi market for characteristic

chemical, microbial and sensory qualities. More than 80% of the samples were adulterated with starch, in addition to wide variation in chemical composition and microbial population.

Technology was developed for commercial production of soft grade Sandesh from buffalo milk. The factors for technology development included fat percentage in milk, temperature of coagulation type of coagulant, methods of draining of whey, grinding of chhana, temperature and duration of heating of chhana and varying types and levels of sugars. The optimized yield of Sandesh from buffalo milk was 27%. Attempts were made to enhance the shelf life of Sandesh with the help of packaging materials and a few safe preservatives. Addition of 0.015% saffron (w/w of chhana) at the terminal stage of heating improved the shelf life of Sandesh upto 9 days at 30° C and 68 days at 7° C with the incorporation of 0.02% BHA. It is now possible to scale up the process of Sandesh for industrial production.

**Sen & Rajorhia (1991)** studied the production of Naramapak Sandesh from buffalo milk with a view to establishing standards for sugar content, milk fat content and heating method during cooking. On the basis of sensory evaluation, best results were obtained using 30% crystalline cane sugar and buffaloes' milk containing 4% milk fat. For a good quality sandesh preparation, slow heating was essential. Addition of chhana in 2 instalments markedly improved body and texture of the finished product. Chemical and microbiological results useful for formulating standards for narampak sandesh production were obtained.

#### **Goat milk.**

**Devangare et al (1994)** prepared chhana from 100:0, 75:25, 50:50, 25:75 and 0:100 mixtures of cow and goat whole milk using 1% citric acid for coagulation, and converted it into sandesh by kneading 250 g fresh chhana with 75 g freshly powdered cane sugar and heating for 20 min to obtain the desired consistency. As the proportion of goat milk increased, decreases were observed in the fat and TS percentage in the milk and in the yield, TS and percentage recovery of TS in the chhana. Goat milk could be used to replace up to 50% of the cow milk without significantly affecting organoleptic properties of the sandesh.

## Soya milk

Mandal *et al*, (1996) Chhana made from soya milk (SM), cow milk (CM), buffalo milk (BM) and 2:1, 1:1 and 1:2 blends of SM with CM or BM, was used to prepare sandesh with 80°C as cooking temperature. SM chhana was unsuitable for preparation of sandesh mainly due to its unacceptable soyabean flavour, but acceptable products were obtained using chhana made from SM blends, particularly 1:1 SM: BM. Sandesh prepared from 1:1 SM: BM was of acceptable quality; it had soft body, very smooth texture and rich appearance, but had perceptible soyabean flavour, and its average composition was 73.6% TS, 14.7% fat, 23.4% protein, 34.1% total carbohydrate and 1.4% ash. Optimum level of sugar addition was 30% by weight of chhana.

## **Composition**

### Laboratory Sandesh

Sen & Rajorhia, (1989) Ten samples of each of 3 varieties of sandesh obtained from the market and 24 samples prepared in the laboratory from cows' and buffaloes' milks were examined for aw, moisture content and sugar content. Average values for aw in the 3 types of market sample were 0.92, 0.81 and 0.95. In laboratory samples, sandesh prepared from cows' milk had a lower aw than that prepared from buffaloes' milk (0.89 vs. 0.92). Partial replacement of cane sugar with the humectant nolen gur (20%) or corn syrup (50%) decreased aw values for laboratory samples of sandesh. Results are discussed with reference to moisture and sugar contents of samples and shelf life of sandesh.

Rajani & Sharada, (1983) prepared chhana from milk that had been boiled, cooled to 80 degree C and then acidified with 1% citric acid until coagulation was complete, or from boiled milk kept at room temperature until acidity developed naturally. Drained curds were used to prepared sandesh and paneer. Protein quality of these products was assessed in rat feeding tests, using skim milk diets as controls. Protein efficiency ratio, biological value and digestibility coefficient of sandesh and paneer were higher than for the control skim milk diets. Sandesh and paneer made from artificially acidified milk had significantly lower biological values than products made from naturally curdled milk.



## Market Sandesh

**Sen & Rajorhia (1990)** presented the studies on the chemical, microbial and sensory quality of sandesh sold in a Delhi market. 3 types of sandesh were examined, i.e. karapak (low moisture, hard), narampak (medium moisture, soft) and kachhagolla (high moisture). Results (tabulated) indicated that moisture level in the 3 types, respectively. (10, 30 and 10 samples analysed, respectively.), averaged approx. 12, 24.5 and 35%; corresponding fat % averaged 21.5, 15 and 12.5, protein % 18, 20 and 12, and sucrose % 46, 36 and 38. Levels of titratable acidity (as % lactic acid) averaged, correspondingly, 0.25, 0.37 and 0.31, levels of free fat (as % of total fat) approx. 82.8, 66.4 and 48, and % of samples giving a positive starch test 10, 10 and 90. Total viable counts in the 3 sandesh types, respectively averaged  $63.66 \times 10$ ,  $10.14 \times 10^{-6}$  and  $15.67 \times 10^{-6}$ ; counts of sporeformers, coliforms, staphylococci, and Oyeasts and moulds (all tabulated) were also considerably higher in narampak and kachhagolla than in karapak. Mean sensory scores for each attribute studied (flavour, body and texture, colour and appearance, sweetness, overall acceptability) were highest [best] for narampak and lowest for karapak. Levels of hardness in the 3 types of sandesh were also evaluated and results indicate the relationship between moisture content and hardness. Pricing of sandesh is briefly discussed.

**Sarkar, (1975)** analysed 20 samples each of (i) soft cooked Sandesh (Narampak) and (ii) hard cooked Sandesh (Karapak) collected in Calcutta. Average % composition of (i) and (ii) was respectively moisture, 23.4 (max. 27.5) and 11.6 (max. 12.8); acidity, as % lactic acid, 0.24 (max. 0.29) and 0.33 (max. 0.37); fat on a DM basis, 23.1 (min. 20.7) and 21.8 (min. 17.8); total sugar, as sucrose on a DM basis, 47.9 (max. 58.0) and 53.0 (max. 56.9); and total proteins (N x 6.38) on a DM basis, 26.1 and 20.5. They suggested that maximum values for moisture, acidity and sugar, and minimum value for fat may be fixed as standard composition. **Banerjee & Sarkar, (1977)** analysed sandesh samples collected from Calcutta market for milk fat, protein and sugar. Soft cooked sandesh samples, when compared with hard cooked samples, contained a high level of moisture (19.1-27.5%) and hence were liable to spoil early. Sugar is the only preservative in sandesh. **Sen & Rajorhia, (1989)** observed that there are three varieties of sandesh, (i) soft-grade (narampak), (ii) hard-grade (karapak) and (iii) kachhagolla, which are sold in Calcutta city, India. Wide variations in chemical composition, microbiological quality and sensory properties

were observed, (ii) had lower moisture, higher sucrose and free-fat content than (i) or (iii). (i) and (iii) were contaminated with staphylococci, spores, yeasts, moulds and coliforms. Microbiological quality of (ii) was best. Sensory score was in the order (i) greater than (iii) greater than (ii). Starchy materials were present in 63.3, 46.7 and 86.7% of samples (i), (ii) and (iii), respectively

### **Shelf life and Packaging**

**Sen & Rajorhia (1990)** studied the effects of various packaging materials such as folding paperboard cartons, polystyrene containers, high density polyethylene bags, nylon-6 pouches and tin cans on the shelf-life of soft grade buffalo milk sandesh [a chhana based milk sweetmeat] stored at 30 plus/minus 1 degree C with 70% RH ('A' condition) and 7 plus/minus 1 degree C with 90% RH ('B' condition). At both storage conditions the max. chemical, microbiological and organoleptic deterioration were found in the sandesh samples packaged in the folding paperboard cartons followed by polystyrene containers, high density polyethylene bags and nylon-6 pouches. Tin cans showed the best results. At 'A' storage conditions sandesh packaged in folding paperboard cartons and tin cans became unacceptable on the 6th day with respect to flavour but their extent of deterioration differed in the 2 packages. At 'B' storage conditions sandesh remained acceptable for up to 30 days in folding paperboard cartons and 45 days in tin cans. Efforts were also made to prepare sandesh free from staphylococci but it was not successful. Acceptability of sandesh reduced during storage, mainly due to flavour deterioration. .

**Sen & Rajorhia (1994)** studied the effect of adding saffron (*Crocus sativus* Linnaleus) at three levels (0.01, 0.015 and 0.02% by weight of chhana) on chemical, microbiological and sensory characteristics of sandesh. The samples were stored at 30±1° C and at 7±1°C, the increased doses of saffron into sandesh slowed down the chemical and microbiological changes under both the conditions of storage. An optimum quantity of 0.015% saffron by weight of chhana is recommended for improving the flavour and shelf life of sandesh.

**Sen & Rajorhia (1996)** incorporated ground cardamom seeds at 0 (control), 0.05, 0.10 and 0.15% by weight of chhana during the last stage of soft sandesh production. The sandesh was aseptically packaged in pre-sterilized lacquered tin cans, and chemical, microbiological and sensory analyses were made periodically

throughout storage at 30 and 7°C. Rate of chemical and microbiological deterioration at both temperatures decreased with increasing level of cardamom, but 0.15% cardamom imparted a strong undesirable odour to the sandesh. Sandesh samples treated with 0.1% cardamom remained acceptable for up to 24 days at 30°C and 85 days at 7°C compared with about 4 and 47 days respectively for control sandesh.

### **Microbiological quality**

**Misra & Kuila, (1988)** studied the microbiological quality of 30 samples of burfi and 25 of sandesh from markets in Nadia, W. Bengal, India. Initial total bacterial counts for burfi and sandesh, respectively, ranged from  $5.0 \times 10^{-2}$  to  $4.4 \times 10^{-5}$  cfu/ml (mean  $1.1 \times 10^{-5}$ ) and from  $30$  to  $2.5 \times 10^{-3}$  cfu/ml (mean  $2.8 \times 10^{-2}$ ). During storage for 72 h at 30 degree C total bacterial counts increased to  $1.3 \times 10^{-7}$  and  $7.93 \times 10^{-3}$  cfu/ml, resp. Approx. 70 and 5% of burfi and sandesh samples, resp., were positive for coagulase-positive Staphylococcus. Initial coliform counts of burfi and sandesh are also given, counts in burfi being much higher than those in sandesh.

**Prajapati & Mathur, (1981)** Ricotta cheese was manufactured using (i) casein whey from buffaloes' skim milk, (ii) Cheddar cheese whey, and (iii) paneer whey, and used to replace 25 or 50% of khoa solids in gulabjaman and 70 or 100% of chhana solids in sandesh. Addition of Ca-2-+ at 100 or 500 p.p.m. to whey systems containing 5% standardized buffaloes' milk (SBM) increased the recovery of protein and TS and yield of Ricotta cheese, but the curd formed when (iii) was used was very fragile; addition of 10% SBM was required for satisfactory curd formation in cheese made from (iii) . Highest organoleptic scores of 96.7, 93 and 93.7% for cheese made with (i), (ii) and (iii), resp., were obtained with 10% SBM and Ca-2-+ at 100 p.p.m. (100 or 500 p.p.m. when (ii) was used). Acceptable quality sandesh could be prepared from 70% (i), (ii) or (iii) + 30% chhana. 50% khoa was necessary to produce gulabjaman of satisfactory quality, the order of suitability of Ricotta cheese as a replacement for khoa being (ii) greater than (i) greater than (iii)

# CHAPTER -III

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Methods & Materials

# **Methods & Materials**

The materials and methods adopted during this investigation are reported in this chapter. This chapter is divided into two main Sections.

**Section 1** comprises of methods and materials adopted for Khoa and Peda,

**Section 2** comprises of methods and materials adopted for Chhana and Sandesh.

## **SECTION 1**

### **KHOA & PEDA:**

#### **A. Manufacture**

- A1. Source of Ingredients
- A2. Method of Manufacture
- A2. Equipment's
- A3. Technique of Preparation

#### **B. Testing**

##### **B1. Testing of Raw Material**

- B1.2 Determination of Fat
- B1.3 Determination of SNF
- B1.4 Determination of Acidity

##### **B2. Testing of Product**

###### **B2.1 Chemical Testing**

###### **B2.1 Chemical Testing of Khoa**

- B2.1.1 Determination of Fat
- B2.1.2 Determination of Moisture
- B2.1.3 Determination of Protein
- B2.1.4 Determination of Lactose

###### **B2.2 Chemical Testing of Peda**

- B2.2.1 Determination of Fat
- B2.2.2 Determination of Moisture
- B2.2.3 Determination of Protein
- B2.2.4 Determination of Lactose

B2.2.5 Determination of Ash

B2.2.6 Determination of Free Fat

B2.2.7 Determination of Yield

**B2.2 Organoleptic Evaluation**

**C. Economics of Product**

**C1. Cost estimation of Khoa and Peda**

**D. Statistical Analysis**

**A. Manufacture**

**A1. Source of Ingredients**

**A1.1 Buffalo Milk:**

Fresh Buffalo milk was obtained from Students Training Dairy, Allahabad Agricultural Institute (Deemed University), Allahabad. It was separated to obtain skim milk.

**A1.2 Vegetable Fat (Saffola):**

Refined oil was obtained from the local market, manufactured by Marico Industries Ltd. Mumbai 400 056.

**A1.3 Sugar was obtained from the local market.**

**A2. Method of Manufacture**

**A2.1.a Standardization of milk:**

Fresh Buffalo milk was standardized to 6% fat and 9% S.N.F. to prepare Khoa, which served as control.

**A2.1.b Filled milk was prepared from Skim milk obtained by separating Buffalo milk.**

Skim milk was tested for fat and S.N.F. The calculated amount of Skim milk powder and vegetable fat were added to it and the composition standardized to three different lots, of 4%, 5% and 6% fat and 9% S.N.F each.. Each of standardized milk were heated to 60 - 65 ° C and then domestic blender (Phillips make) was used to emulsify the vegetable oil with that of Skim milk so as to achieve a homogeneous system of filled milk.

**A2. Equipment's:**

Electric heater, Khunti, Vessel (Degchi), Domestic Blender (Phillips make)

### **A3. Technique of Preparation:**

#### **Preparation of Khoa:**

Khoa was prepared by traditional method as recommended by De & Ray (1952). About 2 litres of milk per operation was convenient to handle in a shallow, open round and heavy bottomed from pan using a brisk, non smoky fire the milk is stirred vigorously and constantly with a circular motion by a Khunti. During this operation all parts of the pan with which the milk comes into contact are lightly scrapped to prevent the milk from scorching. Constant evaporation of moisture takes place and the milk thickens progressively. The heating is continued with greater control and the speed of stirring cum scrapping increased. Soon the viscous mass reaches a semi-solid consistency and begins to dry up. The Khoa pat is invariably made after removing the pan from the fire and working the content up and down into a single compact mass. Thus the four different standardized milk were converted into Khoa by this method.

#### **Preparation of Peda:**

Freshly prepared Khoa was broken into small bits, to this thirty percent by weight of grounded sugar was added. The container was put and cooked over a very non-smoky fire stirring the content with an iron Khunti. When the mixture is ready it was poured into a tray and left to cool and set or shaped as per the desired size.

### **B. Testing**

#### **B1. Testing of Raw Material**

**Buffalo milk and skim milk were tested for:**

**B1.2 Fat:** I S: 1224 Part 1 (1958).

**B1.3 SNF:** Manual of Dairy Chemistry (ICAR), 1972.

**B1.4 Acidity:** Manual of Dairy Chemistry (ICAR), 1972.

#### **B2. Testing of Product**

##### **B2.1 Chemical Testing**

## **B2.1 Chemical Testing of Khoa**

B2.1.1 Determination of Fat IS: 2785 (1979)

B2.1.2 Determination of Moisture: IS: 2785 (1979)

B2.1.3 Determination of Protein: IS: 4079 (1967)

B2.1.4 Determination of Lactose: IS: 2802 (1964)

## **B2.2 Chemical Testing of Peda**

B2.2.1 Determination of Fat IS: 2785 (1979)

B2.2.2 Determination of Moisture IS: 2785 (1979)

B2.2.3 Determination of Protein IS: 4079 (1967)

B2.2.4 Determination of Lactose IS: 2802 (1964)

B2.2.5 Determination of Total sugar: by difference method, Sum of Moisture, Fat, Protein, Ash subtracted from 100.

B2.2.5 Determination of Ash IS: 5162 (1980)

B2.2.6 Determination of Free Fat: Hall & Hedrick (1971)

B2.2.7 Determination of Yield

## **B2.2 Organoleptic Evaluation**

Both control and filled milk Peda were evaluated for sensory score by a panel of five judges drawn from the Faculty of College of Food and Dairy Technology, Department of Dairy Technology. A nine point hedonic scale (See Annexure) was used, to enable the judges to place their scores for overall liking and disliking of Peda for colour and appearance, body and texture, flavour and overall acceptability.

## **C. Economics of Product**

### **C1. Cost estimation of Khoa and Peda**

A systematic cost analysis of control and filled milk Khoa and Peda was undertaken.

## **D. Statistical Analysis**

The data ascertained from the experiments on different parameters were subjected to statistical analysis using analysis of variance technique, two-way classification with one observation per cell. Thereafter, for the tables, which showed significant results, the value of critical difference was computed for comparing all possible combinations



of two treatments at a time where C.D. is statistically defined as:

$$\text{C.D. (a)} \quad \text{S E. (d)} = \sqrt{\frac{2\text{EMSS}}{r}}$$

Where

EMSS = error mean sum of squares

r = no of replications

$$\text{C.D. (b)} \quad \text{S E (d)} \times t (5\%)$$

Where t (5%) = table value of t on error degrees of freedom at 5% probability level.

**Khoa:**

Number of treatments=4

Number of replication=10

Total Number of Trial=40

**Peda:**

Number of treatments=4

Number of replication=10

Total Number of Trial=40

The data obtained were analyzed statistically by using "F" test.

## **SECTION 2**

**CHHANA & SANDESH:**

### **A. Manufacture**

A 1. Source of Ingredients

A 2. Method of Manufacture

A 2. Equipment's

A 3. Technique of Preparation

### **B. Testing**

#### **B 1 Testing of Raw Material**

B1.2 Determination of Fat

B1.3 Determination of SNF

**B1.4 Determination of Acidity**

**B 2 Testing of Product**

**B2.1 Chemical Testing**

**B2.1 Chemical Testing of Chhana**

B2.1.1 Determination of Fat

B2.1.2 Determination of Moisture

B2.1.3 Determination of Protein

**B2.2 Chemical Testing of Sandesh**

B2.2.1 Determination of Fat

B2.2.2 Determination of Moisture

B2.2.3 Determination of Protein

B2.2.4 Determination of Lactose

B2.2.5 Determination of Total sugar

B2.2.5 Determination of Ash

B2.2.6 Determination of Free Fat

B2.2.7 Determination of Yield

**B2.2 Organoleptic Evaluation**

**C. Economics of Product**

**C. Cost estimation of Chhana and Sandesh**

**D. Statistical Analysis**

**A. Manufacture**

**A1. Source of Ingredients**

**A1.1 Cow Milk:**

Fresh Cow milk was obtained from Students Training Dairy, Allahabad Agricultural Deemed University, Allahabad. It was separated to obtain skim milk.

**A1.2 Vegetable Fat (Saffola):**

Refined oil was obtained from the local market, manufactured by Marico Industries Ltd. Mumbai 400 056.

**A1.3 Sugar** was obtained from the local market.

**A1.4 Citric Acid (Laboratory Reagent)** was obtained from the local market of the make Glaxo India.

## **A2. Method of Manufacture**

### **A2.1.a Standardization of milk:**

Fresh Cow milk was standardized to 4% fat and 8.5% S.N.F. to prepare Chhana, which served as control.

**A2.1.b** Filled milk was prepared from Skim milk obtained by separating Cow milk. Skim milk was tested for fat and S.N.F. The calculated amount of Skim milk powder and vegetable fat were added to it and the composition standardized to each lot of 2%, 3% and 4% fat and 8.5% S.N.F. Each of standardized milk were heated to 60 - 65 ° C and then domestic blender (Phillips make) was used to emulsify the vegetable oil with that of Skim milk so as to achieve a homogeneous system of filled milk.

## **A 2. Equipment's:**

Electric heater, Khunti, Vessel (Degchi), Domestic Blender (Phillips make)

## **A 3. Technique of Preparation:**

### **Preparation of Chhana:**

Chhana was prepared by traditional method as recommended by **De & Ray (1954)**. Cow milk and each lot of filled milk (2%, 3%, 4% fat) were heated and coagulated at 82° C with 1% citric acid solution, with constant stirring. When the coagulation is complete, as indicated by the clear whey (greenish colour). The stirring is stopped and the curd is allowed to settle for five minutes. The coagulated mass is collected in a muslin cloth and hung on a peg to drain off the whey. After the whey is completely drain off the Chhana is removed from the muslin cloth.

### **Preparation of Sandesh:**

Break the freshly made Chhana into small bits, add 30% of well grounded sugar to it. Put the mixer into a container and heat on a slow fire, stirring all the time with an iron Khunti. When the mixer is ready pour it in a tray and allow it to or mould it into a desired shape and size.

## **B. Testing**

### **B 1 Testing of Raw Material**

Cow milk and skim milk were tested for:

**B1.2 Fat:** IS: 1224 Part 1 (1970).

**B1.3 SNF:** Manual of Dairy Chemistry (ICAR), 1972.

**B1.4 Acidity:** Manual of Dairy Chemistry (ICAR), 1972.

### **B 2 Testing of Product**

#### **B2.1 Chemical Testing**

##### **B2.1 Chemical Testing of Chhana**

B2.1.1 Determination of Fat: IS: 2785 (1979).

B2.1.2 Determination of Moisture: IS: 2785 (1979)

B2.1.3 Determination of Protein: IS: 4079(1967)

##### **B2.2 Chemical Testing of Sandesh**

B2.2.1 Determination of Fat: IS: 2785 (1979)

B2.2.2 Determination of Moisture: IS: 2785 (1979)

B2.2.3 Determination of Protein: IS: 4079 (1967)

B2.2.4 Determination of Total Sugar: by difference method, Sum of Moisture, Fat, Protein, Ash subtracted from 100.

B2.2.5 Determination of Ash: IS: 5162 (1980)

B2.2.6 Determination of Free Fat: Hall & Hedrick (1971)

B2.2.7 Determination of Yield

##### **B2.2 Organoleptic Evaluation**

Both control and filled milk Sandesh were evaluated for sensory score by a panel of five judges drawn from the Faculty of College of Food and Dairy Technology, Department of Dairy Technology. A nine point hedonic scale (see Annexure) was used, to enable the judges to place their scores for overall liking and disliking of Sandesh for colour and appearance, body and texture, flavour and overall acceptability.

**C. Economics of Product**

**C Cost estimation of Chhana and Sandesh**

A systematic cost analysis of control and filled milk Chhana and Sandesh was undertaken.

**E. Statistical Analysis**

The data ascertained from the experiments on different parameters were subjected to statistical analysis using analysis of variance technique, two-way classification with one observation per cell. Thereafter, for the tables, which showed significant results, the value of critical difference was computed for comparing all possible combinations of two treatments at a time where C.D. is statistically defined as:

$$\text{C.D. (a)} \quad \text{S E.}(\bar{d}) = \sqrt{\frac{2\text{EMSS}}{r}}$$

Where

EMSS = error mean sum of squares

r = no of replications

$$\text{C.D. (b)} \quad \text{S E}(\bar{d}) \times t(5\%)$$

Where t (5%) = table value of t on error degrees of freedom at 5% probability level.

**Chhana:**

Number of treatments=4

Number of replication=10

Total Number of Trial=40

**Sandesh:**

Number of treatments=4

Number of replication=10

Total Number of Trial=40

The data obtained were analyzed statistically by using "F" test.

# CHAPTER-IV

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Results & Discussion

# Results and Discussion

## PHYSIO-CHEMICAL EVALUATION:

### KHOA:

**Moisture Percentage:**

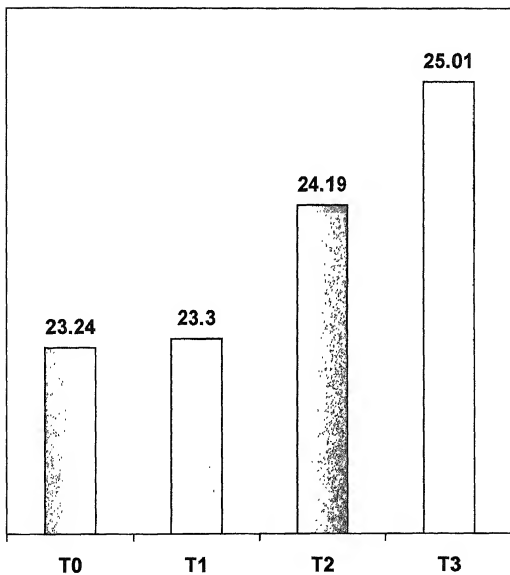
**Table No.1**

**Average moisture percentage of control and experimental Khoa.**

Sl. No.	T <sub>0</sub>	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>
1	22.89	22.95	23.92	24.46
2	24.12	24.46	25.1	25.36
3	24.35	24.55	25.08	25.65
4	22.65	22.78	24.02	24.96
5	23.78	23.03	24.1	25.12
6	23.5	23.45	24.02	25.12
7	23.55	23.65	24.07	25.18
8	22.91	23.12	23.94	24.98
9	22.86	23.05	23.95	24.65
10	21.8	22.05	23.72	24.65
<b>Average</b>	<b>23.24</b>	<b>23.3</b>	<b>24.19</b>	<b>25.01</b>
<b>Minimum</b>	<b>21.8</b>	<b>22.05</b>	<b>23.72</b>	<b>24.46</b>
<b>Maximum</b>	<b>24.35</b>	<b>24.55</b>	<b>25.1</b>	<b>25.65</b>

Moisture percentages of control Khoa (T<sub>0</sub>) ranged from 21.8% to 24.35% with an average of 23.24%. Experimental Khoa (T<sub>1</sub>) had an average of 23.3% moisture with a minimum of 22.05% and a maximum of 24.55%. Experimental Khoa (T<sub>2</sub>) had an average of 24.19% moisture and it ranged from 23.72% to 25.1%. Experimental Khoa (T<sub>3</sub>) had an average of 25.01% moisture, with a minimum of 24.46% and a maximum of 25.65%. The above mentioned results have been shown in Figure No.1

**Average moisture percentage of  
control and experimental Khoa.**



**[Figure.1]**



Data shown in Table No.1 were further analyzed by analysis of variance techniques, results of this analysis is given in Table No.2.

**Table No. 2**

**Analysis of variance of average scores of moisture percentage of control and experimental Khoa.**

Source of variation	D.F.	S.S.	M.S.S.	'F' Cal.	'F' Tab. (5%)	Result
Due to replication	9	11.33	1.25	14.36	2.96	S
Due to treatments	3	21.01	7.00	80.45	2.96	S
Due to error	27	2.36	0.087			
<b>Total</b>	<b>39</b>	<b>34.71</b>				

It is evident from the result of ANOVA given in the Table 2; the variance ratio of 80.45 was greater than the Table value of F (3.27) at 5% level of significance. This indicates that there were significant differences in different treatment combination  $T_0$ ,  $T_1$ ,  $T_2$ , &  $T_3$ . It is concluded that there was significant difference in the moisture percentage of different treatment combination.

The significant differences thus obtained were further analyzed statistically to find out the C.D. between and within the different combinations of control and filled Khoa. Result of C.D. is presented in Table No 3.

**Table No: 3**

**Critical differences in Moisture percentage due to treatment combination of data.**

Treatments	T <sub>0</sub> (23.24)	T <sub>1</sub> (23.30)	T <sub>2</sub> (24.19)
T <sub>3</sub> (25.01)	1.73*	1.66*	0.78*
T <sub>2</sub> (23.30)	0.95*	0.88*	
T <sub>1</sub> (23.24)	0.068		

**C.D.=0.27**

**\*Significant at 5% level**

Table no 3, shows following variations in the Moisture percentage of different treatment combinations.

The difference in mean value of T<sub>0</sub> & T<sub>1</sub> (0.068) is lower than the C.D. (0.27), therefore the difference is non-significant.

The difference in mean value between T<sub>0</sub> & T<sub>2</sub> (0.95) is higher than the C.D. (0.27), therefore the difference is significant.

The difference in mean value of T<sub>0</sub> & T<sub>3</sub> (1.73) is higher than the C.D. (0.27), therefore the difference is significant.

The difference in mean value of T<sub>1</sub> & T<sub>2</sub> (0.88) is higher than the C.D. (0.27), therefore the difference is significant.

The difference in mean value of T<sub>1</sub> & T<sub>3</sub> (1.66) is higher than the C.D. (0.27), therefore the difference is significant.

The difference in mean value of T<sub>2</sub> & T<sub>3</sub> (0.78) is higher than the C.D. (0.27), therefore the difference is significant.

It is therefore, concluded that there was significant differences in the Moisture content of all the treatment combination except the T<sub>0</sub> & T<sub>1</sub> samples as both had the same fat percentage in the milk. The moisture content in the experimental khoa increased in proportion to the decrease in fat level of milk.

## KHOA

Fat percentage:

**Table No.4.**

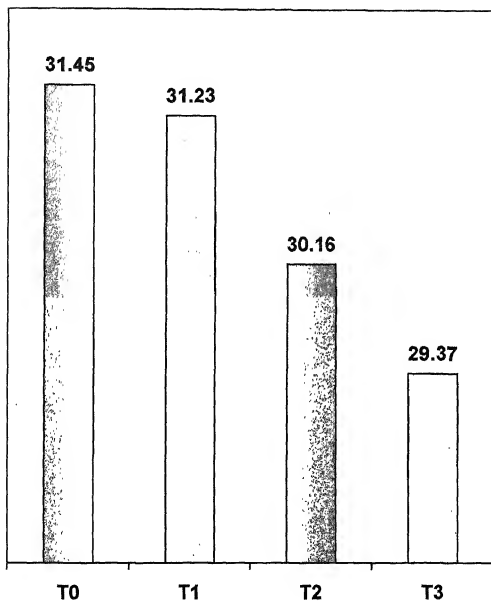
**Average Fat percentage of control and experimental Khoa.**

Sl. No.	T <sub>0</sub>	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>
1	31.4	31.28	30.15	29.54
2	31.45	30.92	29.82	28.42
3	31.25	30.82	30.15	29.46
4	30.92	30.83	29.72	29.02
5	31.15	31.08	29.52	28.23
6	31.05	31.02	29.5	29.02
7	32.15	32.05	31.5	30.92
8	32.2	32.05	30.94	29.84
9	30.86	30.45	29.82	29.18
10	32.08	31.86	30.54	30.1
<b>Average</b>	<b>31.45</b>	<b>31.23</b>	<b>30.16</b>	<b>29.37</b>
<b>Minimum</b>	<b>30.86</b>	<b>30.45</b>	<b>29.5</b>	<b>28.23</b>
<b>Maximum</b>	<b>32.2</b>	<b>32.05</b>	<b>31.5</b>	<b>30.92</b>

It is evident from the Table no 4. that the average fat content of control Khoa is 31.45%, which ranged from 30.86 to 32.20% while in the experimental Khoa (T<sub>1</sub>), average fat percentage is 31.23% and it ranged from 30.45% to 32.05%. The experimental Khoa (T<sub>2</sub>) had an average of 30.16% fat and it had a minimum of 29.5% fat and maximum of 31.5% fat. The experimental Khoa (T<sub>3</sub>) had an average of 29.37 and it had a minimum of 28.23% and a maximum of 30.92%.

The above-mentioned results have been shown in Figure no 2.

### Average Fat percentage of control and experimental Khoa



[Figure.2]

Data shown in Table no 4 were further analyzed by the analysis of variance techniques, results of this analysis is given in Table no.5.

**Table No. 5**

**Analysis of variance of average scores of fat percentage of control and experimental Khoa**

Source of variation	D.F.	S.S.	M.S.S.	'F' Cal.	'F' Tab. (5%)	Result
Due to replication	9	12.51	44.12	580.52	2.96	S
Due to treatments	3	28.15	9.38	123.42	2.96	S
Due to error	27	2.07	0.076			
<b>Total</b>	39	42.73				

It is evident from the results of ANOVA given in Table no.5, the variance ratio 123.42 is greater than the Table value of F (3,27) at 5% level of significance. This shows that there is significant difference in fat content in different treatment combination.

The significant differences thus obtained were further analyzed statistically to find out the C.D. between and within the different treatment combination of the data given in Table No 6.

**Table No: 6**

**Critical differences in Fat percentage due to treatment combination of data.**

Treatments	T <sub>0</sub> (31.45)	T <sub>1</sub> (31.23)	T <sub>2</sub> (30.16)
T <sub>3</sub> (29.37)	2.08*	1.07*	0.79*
T <sub>2</sub> (30.16)	1.29*	1.86*	
T <sub>1</sub> (31.23)	0.22		

**C.D.=0.252**

**\*Significant at 5% level**

Table 6, shows following variations in the fat percentage of different treatment combinations.

Treatment T<sub>0</sub> & T<sub>1</sub> showed the difference (0.22), which is lower value than C.D. (0.252) therefore, the difference is non-significant.

Treatment T<sub>0</sub> & T<sub>2</sub> showed the difference (1.29), which is higher than C.D. (0.252), therefore the difference is significant.

Treatment T<sub>0</sub> & T<sub>3</sub> showed the difference (2.08), which is higher than C.D. (0.252), therefore the difference is significant.

Treatment T<sub>1</sub> & T<sub>2</sub> showed the difference (1.86), which is higher than C.D. (0.252), therefore the difference is significant.

Treatment T<sub>1</sub> & T<sub>3</sub> showed the difference (1.07), which is higher than C.D. (0.252), therefore the difference is significant.

Treatment T<sub>2</sub> & T<sub>3</sub> showed the difference (0.79), which is higher than C.D. (0.252), therefore the difference is significant.

These significant differences may be attributed to the fact that milk of different fat percentage was used to make both control & experimental Khoa.

## KHOA

### Protein Percentage:

Table No.7.

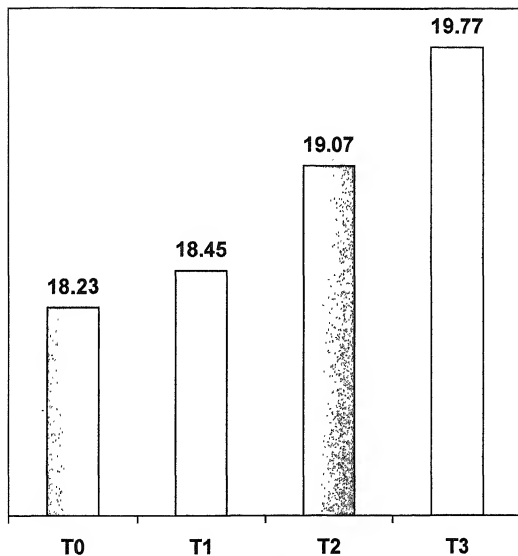
Average protein percentage of control and experimental Khoa.

Sl. No.	T <sub>0</sub>	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>
1	18.48	18.58	18.98	19.12
2	17.67	17.92	18.45	19.1
3	19.2	19.65	20.1	20.23
4	17.75	18.05	18.94	19.65
5	18.45	18.5	19.2	20.18
6	18.36	18.55	19.38	19.76
7	18.68	18.76	19.1	19.95
8	18.1	18.48	19.29	20.12
9	17.96	18.12	19.08	19.86
10	17.72	17.92	18.24	19.81
<b>Average</b>	<b>18.23</b>	<b>18.45</b>	<b>19.07</b>	<b>19.77</b>
<b>Minimum</b>	<b>17.67</b>	<b>17.92</b>	<b>18.24</b>	<b>19.10</b>
<b>Maximum</b>	<b>19.20</b>	<b>19.65</b>	<b>20.10</b>	<b>20.23</b>

It is evident from the data in Table no 7. that the average protein content of control Khoa (T<sub>0</sub>) is 18.23% and it ranged from 17.67% to 19.20%, while in the experimental Khoa (T<sub>1</sub>) the average protein content is 18.45% and it ranged from 17.92% to 19.65%. While in experimental Khoa (T<sub>2</sub>) the average protein content is 19.07% and it ranged from 18.24% to 20.10% in the experimental Khoa (T<sub>3</sub>) the average protein content is 19.77% and it ranged from 19.10% to 20.23%.

The above-mentioned results have been shown in Figure No 3.

### Average protein percentage of control and experimental Khoa



[Figure.3]



Data shown in table No 7. were further analyzed by analysis of variance techniques, results of this analysis is given in Table No. 8.

**Table No.8**

**Analysis of variance of average scores of protein percentage of control and experimental**

Source of variation	D.F.	S.S.	M.S.S.	'F' Cal.	'F' Tab. (5%)	Result
Due to replication	9	6.54	3.24	50.62	2.96	S
Due to treatments	3	14.41	4.80	75.00	2.96	S
Due to error	27	1.73	0.64			
<b>Total</b>	39	22.68				

It is evident from the results of ANOVA given in Table no 8. the variance ratio 75.00 is greater than the Table value of F (3.27) at 5% level of significance. This shows that there is significant difference in Protein content in different treatment combination.

The significant differences thus obtained were further analyzed statistically to find out the C.D. between and within the different treatment combination of the data given in Table no 9.

**Table No: 9**

**Critical differences in Protein percentage due to treatment combination of data.**

<b>Treatments</b>	<b>T<sub>0</sub> (18.23)</b>	<b>T<sub>1</sub>(18.45)</b>	<b>T<sub>2</sub>(19.07)</b>
<b>T<sub>3</sub>(19.77)</b>	1.54*	1.32*	0.70*
<b>T<sub>2</sub>(19.07)</b>	0.84*	0.62*	
<b>T<sub>1</sub>(18.45)</b>	0.22		

**C.D.=0.23**

**\*Significant at 5% level**

Table No 9 shows following variations in the Protein percentage of different treatment combinations.

Treatment T<sub>0</sub> & T<sub>1</sub> showed the difference (0.22), which is lower value than C.D. (0.23) therefore, the difference is non-significant.

Treatment T<sub>0</sub> & T<sub>2</sub> showed the difference (0.84), which is higher than C.D. (0.23), therefore the difference is significant.

Treatment T<sub>0</sub> & T<sub>3</sub> showed the difference (1.54), which is higher than C.D. (0.23), therefore the difference is significant.

Treatment T<sub>1</sub> & T<sub>2</sub> showed the difference (0.62), which is higher than C.D. (0.23), therefore the difference is significant.

Treatment T<sub>1</sub> & T<sub>3</sub> showed the difference (1.32), which is higher than C.D. (0.23), therefore the difference is significant.

Treatment T<sub>2</sub> & T<sub>3</sub> showed the difference (0.70), which is higher than C.D. (0.23), therefore the difference is significant.

## KHOA

Lactose Percentage:

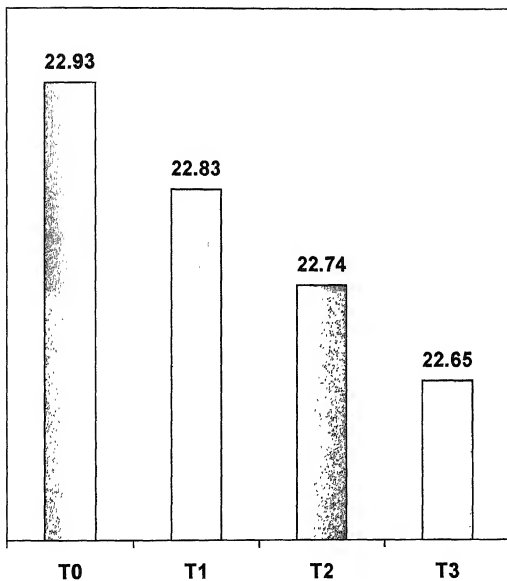
Table No.10

Average Lactose percentage of control and experimental Khoa.

Sl. No.	T <sub>0</sub>	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>
1	22.85	23.02	22.66	22.94
2	23.45	23.12	22.87	22.95
3	22.42	22.87	23.21	23.15
4	23.09	22.97	22.63	23.13
5	23.1	23.2	22.52	22.23
6	22.98	23.08	22.56	22.15
7	22.57	22.1	22.54	22.25
8	22.65	22.17	22.5	22.25
9	23.12	23.28	22.96	22.82
10	23.14	22.5	22.95	22.72
<b>Average</b>	<b>22.93</b>	<b>22.83</b>	<b>22.74</b>	<b>22.65</b>
<b>Minimum</b>	<b>22.42</b>	<b>22.1</b>	<b>22.5</b>	<b>22.15</b>
<b>Maximum</b>	<b>23.45</b>	<b>23.28</b>	<b>23.21</b>	<b>23.15</b>

Lactose percentages of control Khoa (T<sub>0</sub>) ranged from 22.93% to 22.42% with an average of 23.45%. Experimental Khoa (T<sub>1</sub>) had an average lactose percentage of 22.83% with a minimum of 22.10% and a maximum of 23.28%. Experimental Khoa (T<sub>2</sub>) had an average lactose percentage of 22.74% and it ranged from 22.50% to 23.21%. Experimental Khoa (T<sub>3</sub>) had an average of 22.65% with a minimum of 22.15% and a maximum of 23.15%. The above mentioned results have been shown in Figure No.4

### Average Lactose percentage of control and experimental Khoa



[Figure.4]

Data shown in Table No.10 were further analyzed by analysis of variance techniques, results of this analysis is given in Table No.11.

**Table No.11**

**Analysis of variance of average scores of Lactose percentage of control and experimental**

Source of variation	D.F.	S.S.	M.S.S.	'F' Cal.	'F' Tab. (5%)	Result
Due to replication	9	2.00	0.222	2.61	2.96	N.S
Due to treatments	3	0.432	0.144	1.64	2.96	N.S
Due to error	27	2.31	0.085			
<b>Total</b>	<b>39</b>	<b>4.75</b>				

It is evident from the results of ANOVA given in Table No.11, the variance ratio 1.64 is lower than the Table value of F (3.27) at 5% level of significance. This shows that there is no significant difference in lactose content in different treatment combination.'

## KHOA

Yield Percentage:

Table No.12.

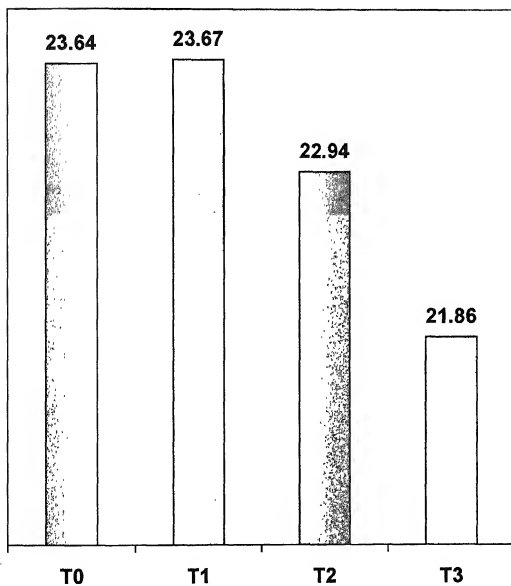
Average yield percentage of control and experimental Khoa.

Sl. No.	T <sub>0</sub>	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>
1	22.7	22.6	22.3	21.5
2	23.2	23.5	22.7	22.0
3	23.5	23.7	23.0	22.1
4	23.7	23.9	22.9	22.4
5	23.4	23.5	22.1	21.8
6	23.7	23.5	23.1	22.2
7	24.1	23.9	23.5	21.2
8	24.0	24.2	23.1	21.7
9	24.2	23.8	23.2	22.1
10	23.9	24.1	23.5	21.6
<b>Average</b>	<b>23.64</b>	<b>23.67</b>	<b>22.94</b>	<b>21.86</b>
<b>Minimum</b>	<b>22.7</b>	<b>22.6</b>	<b>22.1</b>	<b>21.2</b>
<b>Maximum</b>	<b>24.2</b>	<b>24.2</b>	<b>23.5</b>	<b>22.4</b>

It is evident from the data in Table no 11. that the average yield of control Khoa (T<sub>0</sub>) is 23.64% and it ranged from 22.7% to 24.2%, while in the experimental Khoa (T<sub>1</sub>) the average yield is 23.67% and it ranged from 22.6% to 24.2%. While in experimental Khoa (T<sub>2</sub>) the average yield is 22.94% and it ranged from 22.1% to 23.5% in the experimental Khoa (T<sub>3</sub>) the average yield is 21.86% and it ranged from 21.2% to 22.4%.

The above-mentioned results have been shown in Figure No 5.

### Average yield percentage of control and experimental Khoa



[Figure.5]

Data shown in table No 12. were further analyzed by analysis of variance techniques, results of this analysis is given in Table No. 13.

**Table No.13**

**Analysis of variance of average yield of control and experimental**

Source of variation	D.F.	S.S.	M.S.S.	'F' Cal.	'F' Tab. (5%)	Result
Due to replication	9	3.90	4.34	4.01	2.96	S
Due to treatments	3	21.58	71.95	66.62	2.96	S
Due to error	27	2.92	1.08			
<b>Total</b>	<b>39</b>	<b>28.42</b>				

It is evident from the results of ANOVA given in Table no 13. the variance ratio 66.62 is greater than the Table value of F (3.27) at 5% level of significance. This shows that there is significant difference in yield percentage of different treatment combination.

The significant differences thus obtained were further analyzed statistically to find out the C.D. between and within the different treatment combination of the data given in Table no 14.



**Table No: 14**

**Critical differences in yield percentage due to treatment combination of data.**

<b>Treatments</b>	<b>T<sub>0</sub> (23.64)</b>	<b>T<sub>1</sub>(23.67)</b>	<b>T<sub>2</sub>(22.94)</b>
<b>T<sub>3</sub>(21.86)</b>	1.78*	1.81*	1.08*
<b>T<sub>2</sub>(22.94)</b>	0.7	0.73	
<b>T<sub>1</sub>(23.67)</b>	0.03		

**C.D.=0.94**

**\*Significant at 5% level**

Table No 14 shows following variations in the yield of different treatment combinations.

Treatment T<sub>0</sub> & T<sub>1</sub> showed the difference (0.03), which is lower value than C.D. (0.94) therefore, the difference is non-significant.

Treatment T<sub>0</sub> & T<sub>2</sub> showed the difference (0.7), which is lower than C.D. (0.94), therefore the difference is significant.

Treatment T<sub>0</sub> & T<sub>3</sub> showed the difference (1.78), which is higher than C.D. (0.94), therefore the difference is significant.

Treatment T<sub>1</sub> & T<sub>2</sub> showed the difference (0.73), which is lower than C.D. (0.94), therefore the difference is significant.

Treatment T<sub>1</sub> & T<sub>3</sub> showed the difference (1.81), which is higher than C.D. (0.94), therefore the difference is significant.

Treatment T<sub>2</sub> & T<sub>3</sub> showed the difference (1.08), which is higher than C.D. (0.94), therefore the difference is significant.

## PEDA

### Moisture percentage

TABLE NO: 15

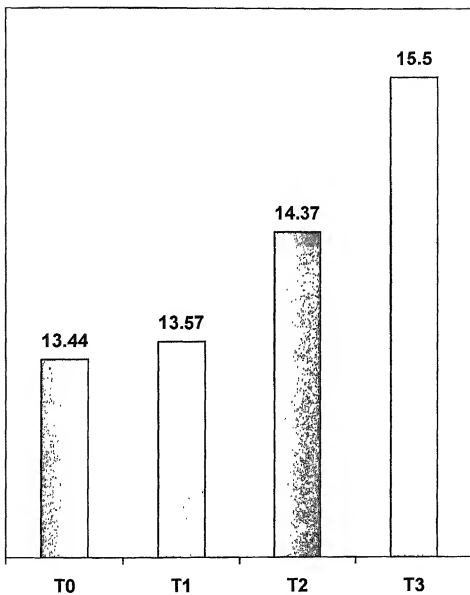
Average moisture percentage in control and experimental Peda.

Sl No.	T0	T1	T2	T3
1	13.09	13.2	14.1	15
2	14.32	14.71	15.28	15.9
3	14.55	14.88	15.26	16.19
4	12.85	13.03	14.2	15.5
5	13.98	13.28	14.28	15.66
6	13.7	13.7	14.2	15.67
7	13.75	13.9	14.25	15.72
8	13.11	13.37	14.12	15.04
9	13.06	13.33	14.13	15.19
10	12	12.3	13.9	15.19
<b>Average</b>	13.44	13.57	14.37	15.5
<b>Minimum</b>	12	12.3	13.9	15
<b>Maximum</b>	14.55	14.88	15.28	16.19

It is evident from the data in Table No 15. that the average moisture content of control Peda ( $T_0$ ) was 13.44% and it ranged from 12% to 14.55%, while in the experimental peda ( $T_1$ ) the average moisture content is 13.57% and it ranged from 12.3% to 14.88%, while in experimental Peda ( $T_2$ ) the average moisture content is 14.37% and it ranged from 13.90% to 15.28%, in the experimental Peda ( $T_3$ ) the average moisture content is 15.50% and it ranged from 15.00% to 16.19%.

The above mentioned results have been shown in Figure no.6

**Average moisture percentage in  
control and experimental Peda**



**[Figure.6]**

Data shown in Table No.15 were further analyzed by analysis of variance techniques, results of this analysis is given in Table No.16

**Table No.16**

**Analysis of variance of average scores of moisture percentage of control and experimental Peda.**

Source of variation	D.F.	S.S.	M.S.S.	'F' Cal.	'F' Tab. (5%)	Result
Due to replication	9	11.72	1.30	13.00	2.96	S
Due to treatments	3	27.06	9.02	902	2.96	S
Due to error	27	2.41	0.100			
<b>Total</b>	39	41.19				

It is evident from the results of ANOVA given in Table No.16 the variance ratio 902 is greater than the Table value of F (3.27) at 5% level of significance. This shows that there is significant difference in moisture content in different treatment combination.

The significant differences thus obtained were further analyzed statistically to find out the C.D. between and within the different treatment combination of the data given in Table No.17.

**Table No: 17**

**Critical differences in moisture percentage due to treatment combination of data.**

<b>Treatments</b>	<b>T<sub>0</sub> (13.44)</b>	<b>T<sub>0</sub>(13.57)</b>	<b>T<sub>2</sub>(14.37)</b>
<b>T<sub>3</sub>(15.50)</b>	2.06*	1.93*	1.13*
<b>T<sub>2</sub>(14.37)</b>	0.93*	0.80*	
<b>T<sub>1</sub>(13.57)</b>	0.13		

**C.D.=0.29**

**\*Significant at 5% level**

Table No 17, shows following variations in the moisture percentage of different treatment combinations.

Treatment T<sub>0</sub> & T<sub>1</sub> showed the difference (0.13), which is lower value than C.D. (0.29) therefore, the difference is non-significant

Treatment T<sub>0</sub> & T<sub>2</sub> showed the difference (0.93), which is higher than C.D. (0.29), therefore the difference is significant.

Treatment T<sub>0</sub> & T<sub>3</sub> showed the difference (2.06), which is higher than C.D. (0.29), therefore the difference is significant

Treatment T<sub>1</sub> & T<sub>2</sub> showed the difference (0.80), which is higher than C.D. (0.29), therefore the difference is significant.

Treatment T<sub>1</sub> & T<sub>3</sub> showed the difference (1.93), which is higher than C.D. (0.29), therefore the difference is significant.

Treatment T<sub>2</sub> & T<sub>3</sub> showed the difference (1.13), which is higher than C.D. (0.29), therefore the difference is significant.

## PEDA

### Fat Percentage

Table No: 18.

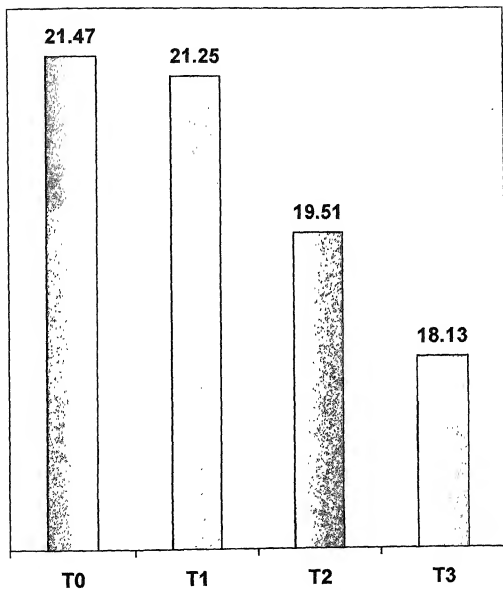
Average fat percentage in control and experimental Peda.

Sl. No.	T <sub>0</sub>	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>
1	21.42	21.3	19.5	18.3
2	21.47	20.94	19.17	17.18
3	21.27	20.84	19.5	18.22
4	20.94	20.85	19.07	17.78
5	21.17	21.1	18.87	16.99
6	21.07	21.04	18.85	17.78
7	22.17	22.07	20.85	19.68
8	22.22	22.07	20.29	18.6
9	20.88	20.47	19.17	17.94
10	22.1	21.88	19.89	18.86
<b>Average</b>	<b>21.47</b>	<b>21.25</b>	<b>19.51</b>	<b>18.13</b>
<b>Minimum</b>	<b>22.22</b>	<b>22.07</b>	<b>20.85</b>	<b>19.68</b>
<b>Maximum</b>	<b>20.88</b>	<b>20.47</b>	<b>18.85</b>	<b>16.99</b>

It is evident from the data in Table No.18 that the average fat content of control Peda (T<sub>0</sub>) is 21.47% and it ranged from 20.88% to 22.22%, while in the experimental peda (T<sub>1</sub>) the average fat content is 21.25% and it ranged from 20.47% to 22.07%. While in experimental Peda (T<sub>2</sub>) the average fat content is 19.51% and it ranged from 18.85% to 20.85% in the experimental Peda (T<sub>3</sub>) the average fat content is 18.13% and it ranged from 16.99% to 19.68%.

The above mentioned results have been shown in Figure no.7

### Average fat percentage in control and experimental Peda



[Figure.7]

Data shown in Table No.18 were further analyzed by analysis of variance techniques, results of this analysis is given in Table No.19.

**Table No.19**

**Analysis of variance of average scores of fat percentage of control and experimental.**

Source of variation	D.F.	S.S.	M.S.S.	'F' Cal.	'F' Tab. (5%)	Result
Due to replication	9	12.50	1.38	17.03	2.96	S
Due to treatments	3	74.26	24.75	305.55	2.96	S
Due to error	27	2.21	0.081			
<b>Total</b>	<b>39</b>	<b>88.96</b>				

It is evident from the results of ANOVA given in Table no.19, the variance ratio 305.55 is greater than the Table value of F (3.27) at 5% level of significance. This shows that there is significant difference in fat content in different treatment combination.

The significant differences thus obtained were further analyzed statistically to find out the C.D. between and within the different treatment combination of the data given in Table No 20.



**Table No: 20.**

**Critical differences in fat percentage due to treatment combination of data.**

<b>Treatments</b>	<b>T<sub>0</sub> (21.47)</b>	<b>T<sub>1</sub>(21.25)</b>	<b>T<sub>2</sub>(19.51)</b>
<b>T<sub>3</sub>(18.13)</b>	3.34*	3.12*	1.38*
<b>T<sub>2</sub>(19.51)</b>	1.96*	1.74*	
<b>T<sub>1</sub>(21.25)</b>	0.22		

**C.D.=0.26**

**\*Significant at 5% level**

Table No 20, shows following variations in the moisture percentage of different treatment combinations.

Treatment T<sub>0</sub> & T<sub>1</sub> showed the difference (0.22), which is lower value than C.D. (0.26) therefore, the difference is non-significant.

Treatment T<sub>0</sub> & T<sub>2</sub> showed the difference (1.96), which is higher than C.D. (0.26), therefore the difference is significant.

Treatment T<sub>0</sub> & T<sub>3</sub> showed the difference (3.34), which is higher than C.D. (0.26), therefore the difference is significant

Treatment T<sub>1</sub> & T<sub>2</sub> showed the difference (1.74), which is higher than C.D. (0.26), therefore the difference is significant.

Treatment T<sub>1</sub> & T<sub>3</sub> showed the difference (3.12), which is higher than C.D. (0.26), therefore the difference is significant.

Treatment T<sub>2</sub> & T<sub>3</sub> showed the difference (1.38), which is higher than C.D. (0.26), therefore the difference is significant.

## PEDA

### Protein percentage

Table No: 21.

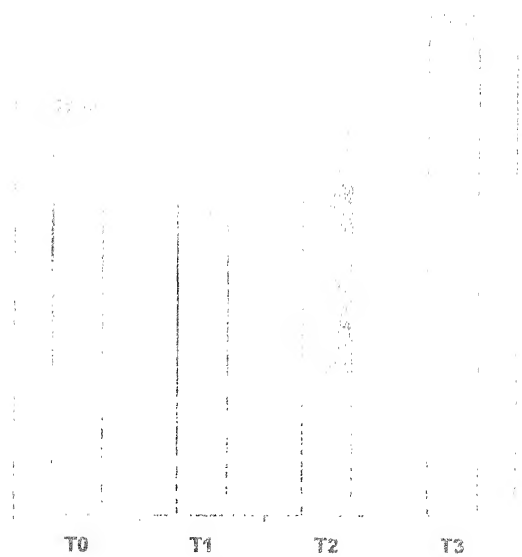
Average protein percentage in experimental and control Peda.

Sl. No.	T <sub>0</sub>	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>
1	12.8	12.8	13.7	14.9
2	11.99	12.04	13.17	14.88
3	13.52	13.87	14.82	16.01
4	12.07	12.27	13.66	15.43
5	12.77	12.72	13.92	15.96
6	12.68	12.77	14.1	15.54
7	13	12.98	13.82	15.73
8	12.42	12.7	14.01	15.9
9	12.28	12.34	13.8	15.64
10	12.04	12.14	12.96	15.59
<b>Average</b>	<b>12.55</b>	<b>12.66</b>	<b>13.79</b>	<b>15.55</b>
<b>Minimum</b>	<b>11.99</b>	<b>12.04</b>	<b>12.96</b>	<b>14.88</b>
<b>Maximum</b>	<b>13.52</b>	<b>13.87</b>	<b>14.82</b>	<b>16.01</b>

It is evident from the data in Table No.21. that the average protein content of control Peda (T<sub>0</sub>) is 12.55% and it ranged from 11.99% to 13.52%, while in the experimental peda (T<sub>1</sub>) the average protein content is 12.66% and it ranged from 12.04% to 13.87%. While in experimental Peda (T<sub>2</sub>) the average protein content is 13.79% and it ranged from 12.96% to 14.82% in the experimental Peda (T<sub>3</sub>) the average protein content is 15.55% and it ranged from 14.88% to 16.01%.

The above mentioned results have been shown in Figure No.8.

Figure 8.1: A diagram showing the relationship between the variables  $T_0$ ,  $T_1$ ,  $T_2$ , and  $T_3$ .



[Figure.8]

Data shown in Table No 21. were further analyzed by analysis of variance techniques, results of this analysis is given in Table no.22

**Table No.22.**

**Analysis of variance of average scores of protein percentage of control and experimental.**

Source of variation	D.F.	S.S.	M.S.S.	'F' Cal.	'F' Tab. (5%)	Result
Due to replication	9	6.65	0.73	1.12	2.96	N.S
Due to treatments	3	58.30	19.40	298	2.96	S
Due to error	27	1.78	0.065			
<b>Total</b>	39	66.73				

It is evident from the results of ANOVA given in Table No.22, the variance ratio 298 is greater than the Table value of F (3.27) at 5% level of significance. This shows that there is significant difference in protein content in different treatment combination.

The significant differences thus obtained were further analyzed statistically to find out the C.D. between and within the different treatment combination of the data given in Table No 23.

**Table No: 23.**

**Critical differences in protein percentage due to treatment combination of data.**

Treatments	T <sub>0</sub> (12.55)	T <sub>1</sub> (12.66)	T <sub>2</sub> (13.79)
T <sub>3</sub> (15.58)	3.03*	2.92*	1.79*
T <sub>2</sub> (13.79)	1.24*	1.13*	
T <sub>1</sub> (12.66)	0.11		

**C.D.=0.23**

**\*Significant at 5% level**

Table No 23, shows following variations in the protein percentage of different treatment combinations.

Treatment T<sub>0</sub> & T<sub>1</sub> showed the difference (0.11), which is lower value than C.D. (0.23) therefore, the difference is non-significant.

Treatment T<sub>0</sub> & T<sub>2</sub> showed the difference (1.24), which is higher than C.D. (0.23), therefore the difference is significant.

Treatment T<sub>0</sub> & T<sub>3</sub> showed the difference (3.03), which is higher than C.D. (0.23), therefore the difference is significant

Treatment T<sub>1</sub> & T<sub>2</sub> showed the difference (1.13), which is higher than C.D. (0.23), therefore the difference is significant.

Treatment T<sub>1</sub> & T<sub>3</sub> showed the difference (2.92), which is higher than C.D. (0.23), therefore the difference is significant.

Treatment T<sub>2</sub> & T<sub>3</sub> showed the difference (1.79), which is higher than C.D. (0.23), therefore the difference is significant.

## PEDA

### Total Sugar percentage

Table No: 24

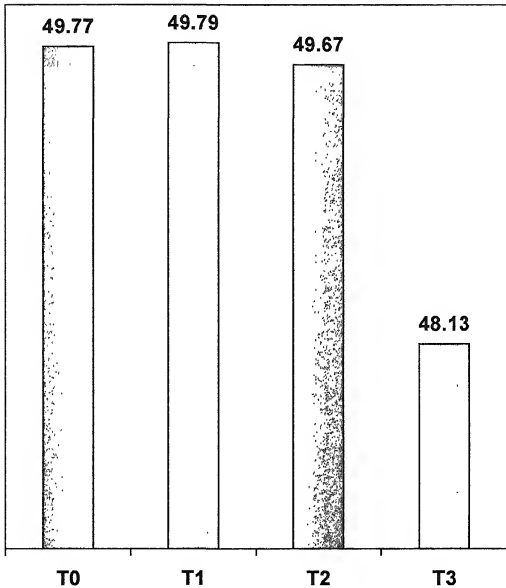
Average total sugar percentage in Experimental and Control Peda.

Sl. No.	T <sub>0</sub>	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>
1	49.89	50.1	50.2	49.3
2	49.32	49.61	49.88	49.24
3	47.86	47.71	47.62	47.08
4	51.24	51.15	50.47	48.59
5	49.18	50.1	50.23	48.69
6	49.75	49.89	50.15	48.21
7	48.28	48.25	48.28	46.17
8	49.65	49.06	49.18	47.76
9	51.38	51.06	50.1	48.43
10	51.16	50.98	50.65	47.86
<b>Average</b>	<b>49.77</b>	<b>49.79</b>	<b>49.67</b>	<b>48.13</b>
<b>Minimum</b>	<b>47.86</b>	<b>47.71</b>	<b>47.6</b>	<b>47.08</b>
<b>Maximum</b>	<b>51.38</b>	<b>51.15</b>	<b>50.47</b>	<b>49.30</b>

It is evident from the data in Table No 24 that the average total sugar content of control Peda (T<sub>0</sub>) was 49.77% and it ranged from 47.86% to 51.38%, while in the experimental peda (T<sub>1</sub>) the average total sugar content is 49.79% and it ranged from 47.71% to 51.15%. While in experimental Peda (T<sub>2</sub>) the average total sugar content is 49.67% and it ranged from 47.62% to 50.47% in the experimental Peda (T<sub>3</sub>) the average total sugar content is 48.13% and it ranged from 47.08% to 49.30%

The above mentioned results have been shown in Figure No.9

**Average total sugar percentage in  
Experimental and Control Peda**



**[Figure.9]**

Data shown in Table No.24 were further analyzed by analysis of variance techniques, results of this analysis is given in Table No.25.

**Table No: 25.**

**Analysis of variance of average scores of Total sugar percentage of control and experimental.**

Source of variation	D.F.	S.S.	M.S.S.	'F' Cal.	'F' Tab. (5%)	Result
Due to replication	9	35.15	3.90	16.04	2.96	S
Due to treatments	3	20.59	6.86	28.83	2.96	S
Due to error	27	6.58	0.243			
<b>Total</b>	39	62.32				

It is evident from the results of ANOVA given in Table no.25 the variance ratio 28.83 is greater than the Table value of F (3.27) at 5% level of significance. This shows that there is significant difference in Total sugar content in different treatment combination.

The significant differences thus obtained were further analyzed statistically to find out the C.D. between and within the different treatment combination of the data given in Table No 26.



**Table No: 26**

**Critical differences in Total Sugar percentage due to treatment combination of data.**

<b>Treatments</b>	<b>T<sub>0</sub> (49.77)</b>	<b>T<sub>1</sub>(49.79)</b>	<b>T<sub>2</sub>(49.67)</b>
<b>T<sub>3</sub>(48.13)</b>	1.64*	1.66*	1.54*
<b>T<sub>2</sub>(49.67)</b>	0.10	0.12	
<b>T<sub>1</sub>(49.97)</b>	0.20		

**C.D.=0.45**

**\*Significant at 5% level**

Table No 26, shows following variations in the total sugar percentage of different treatment combinations.

Treatment T<sub>0</sub> & T<sub>1</sub> showed the difference (0.20), which is lower value than C.D. (0.45) therefore, the difference is non-significant

Treatment T<sub>0</sub> & T<sub>2</sub> showed the difference (0.10), which is lower than C.D. (0.45), therefore the difference is non-significant.

Treatment T<sub>0</sub> & T<sub>3</sub> showed the difference (1.64), which is higher than C.D. (0.45), therefore the difference is significant

Treatment T<sub>1</sub> & T<sub>2</sub> showed the difference (0.12), which is lower than C.D. (0.45), therefore the difference is non-significant.

Treatment T<sub>1</sub> & T<sub>3</sub> showed the difference (1.66), which is higher than C.D. (0.45), therefore the difference is significant.

Treatment T<sub>2</sub> & T<sub>3</sub> showed the difference (1.54), which is higher than C.D. (0.45), therefore the difference is significant.

## PEDA

### Ash Percentage

Table No: 27.

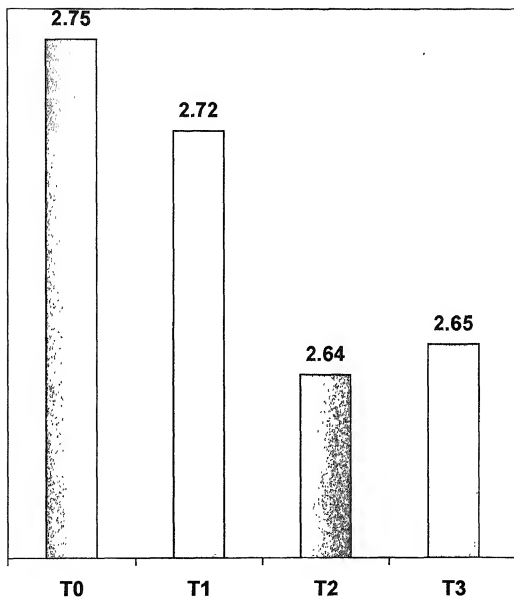
Average percentage of Ash in Experimental and Control Peda.

SL No.	T <sub>0</sub>	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>
1	2.8	2.6	2.5	2.5
2	2.9	2.7	2.5	2.8
3	2.8	2.7	2.8	2.5
4	2.8	2.7	2.6	2.7
5	2.9	2.8	2.7	2.7
6	2.8	2.6	2.7	2.8
7	2.8	2.8	2.8	2.7
8	2.6	2.8	2.4	2.7
9	2.4	2.8	2.8	2.6
10	2.7	2.7	2.6	2.5
Average	2.75	2.72	2.64	2.65
Maximum	2.90	2.80	2.80	2.8
Minimum	2.40	2.60	2.40	2.4

It is evident from the data in Table No 27. that the average Ash content of control Peda (T<sub>0</sub>) is 2.75% and it ranged from 2.4% to 2.9%, while in the experimental peda (T<sub>1</sub>) the average Ash content is 2.72% and it ranged from 2.6% to 2.8%. While in experimental Peda (T<sub>2</sub>) the average Ash content is 2.64% and it ranged from 2.4% to 2.8% in the experimental Peda (T<sub>3</sub>) the average Ash content is 2.65% and it ranged from 2.4% to 2.8%.

The above mentioned results have been shown in Figure No.10

**Average percentage of Ash in  
Experimental and Control Peda**



**[Figure.10]**

Data shown in Table No.27 were further analyzed by analysis of variance techniques, results of this analysis is given in Table No.28.

**Table No: 28.**

**Analysis of variance of average scores of Ash percentage of control and experimental**

Source of variation	D.F.	S.S.	M.S.S.	'F' Cal.	'F' Tab. (5%)	Result
Due to replication	9	0.13	0.014	0.823	2.96	N.S
Due to treatments	3	0.084	0.028	1.64	2.96	N.S
Due to error	27	0.476	0.017			
<b>Total</b>	39	0.69				

It is evident from the results of ANOVA given in Table No.28 the variance ratio 1.64 is lower than the Table value of F (3.27) at 5% level of significance. This shows that there is no significant difference in Ash content in different treatment combination.

## PEDA

### FREE FAT

Table No: 29.

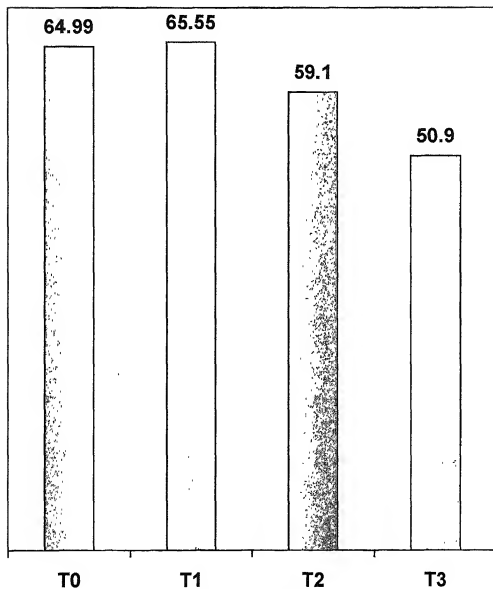
Average free fat in experimental and control Peda.

Sl. No.	T <sub>0</sub>	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>
1	64.56	64.22	59.32	50.33
2	65.71	65.71	60.12	51.76
3	67.12	68.32	59.76	52.11
4	64.12	66.45	59.32	51.37
5	65.32	66.72	58.55	51.15
6	64.76	66.51	58.72	50.75
7	64.12	64.07	58.21	50.22
8	65.19	65.17	59.55	49.87
9	64.76	64.32	59.75	50.07
10	64.32	64.01	57.79	51.37
<b>Average</b>	<b>64.99</b>	<b>65.55</b>	<b>59.10</b>	<b>50.90</b>
<b>Minimum</b>	<b>64.12</b>	<b>64.01</b>	<b>57.79</b>	<b>49.87</b>
<b>Maximum</b>	<b>67.12</b>	<b>68.32</b>	<b>60.12</b>	<b>52.11</b>

It is evident from the data in Table No.29 that the average free fat content of control Peda (T<sub>0</sub>) was 64.99% and it ranged from 64.12% to 67.12%, while in the experimental Peda (T<sub>1</sub>) the average free fat content is 65.55% and it ranged from 64.01% to 68.32%. While in experimental Peda (T<sub>2</sub>) the average free fat content is 59.10% and it ranged from 57.79% to 60.12% in the experimental Peda (T<sub>3</sub>) the average free fat content is 50.90% and it ranged from 49.87% to 52.11%.

The above mentioned results have been shown in Figure No.11

### Average free fat in experimental and control Peda



[Figure.11]

Data shown in Table No 29. were further analyzed by analysis of variance techniques, results of this analysis is given in Table no. 30.

**Table No.30.**

**Analysis of variance of average scores of Free fat percentage of control and experimental Peda.**

Source of variation	D.F.	S.S.	M.S.S.	'F' Cal.	'F' Tab. (5%)	Result
Due to replication	9	22.09	2.45	4.62	2.96	S
Due to treatments	3	1393.09	464.36	876.15	2.96	S
Due to error	27	14.41	0.53			
<b>Total</b>	<b>39</b>	<b>1429.57</b>				

It is evident from the results of ANOVA given in Table no. 30, the variance ratio 876.15 is greater than the Table value of F (3.27) at 5% level of significance. This shows that there is significant difference in free fat content in different treatment combination.

The significant differences thus obtained were further analyzed statistically to find out the C.D. between and within the different treatment combination of the data given in Table No 31.

**Table No: 31.**

**Critical differences in free fat percentage due to treatment combination of data.**

Treatments	T <sub>0</sub> (64.99)	T <sub>1</sub> (65.50)	T <sub>2</sub> (59.10)
T <sub>3</sub> (50.90)	14.09*	14.60*	8.2*
T <sub>2</sub> (59.10)	5.89*	6.4*	
T <sub>1</sub> (65.50)	0.51		

**C.D.=0.65**

**\*Significant at 5% level**

Table No 31, shows following variations in the free fat percentage of different treatment combinations.

Treatment T<sub>0</sub> & T<sub>1</sub> showed the difference (0.51), which is lower value than C.D. (0.65) therefore, the difference is non-significant.

Treatment T<sub>0</sub> & T<sub>2</sub> showed the difference (5.89), which is lower than C.D. (0.65), therefore the difference is significant.

Treatment T<sub>0</sub> & T<sub>3</sub> showed the difference (14.09), which is higher than C.D. (0.65), therefore the difference is significant

Treatment T<sub>1</sub> & T<sub>2</sub> showed the difference (6.4), which is lower than C.D. (0.65), therefore the difference is significant.

Treatment T<sub>1</sub> & T<sub>3</sub> showed the difference (14.60), which is higher than C.D. (0.65), therefore the difference is significant.

Treatment T<sub>2</sub> & T<sub>3</sub> showed the difference (8.2), which is higher than C.D. (0.65), therefore the difference is significant.



## PEDA

### Lactose percentage

Table No: 32.

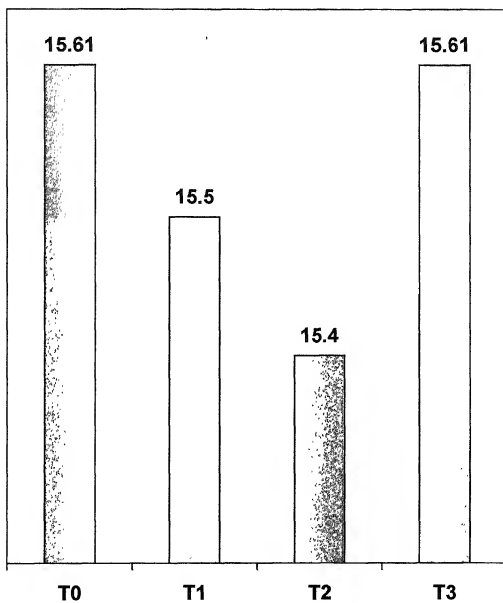
Average percentage of lactose in experimental and control Peda.

Sl. No.	T <sub>0</sub>	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>
1	15.53	15.7	15.4	15.9
2	16.13	15.78	15.61	15.91
3	15.1	15.55	15.65	16.11
4	15.77	15.65	15.37	16.09
5	15.78	14.88	15.26	15.19
6	15.66	15.76	15.3	15.11
7	15.25	14.78	15.28	15.21
8	15.33	15.33	14.79	15.21
9	15.8	15.82	15.7	15.78
10	15.82	15.82	15.69	15.68
<b>Average</b>	<b>15.61</b>	<b>15.5</b>	<b>15.4</b>	<b>15.61</b>
<b>Maximum</b>	<b>16.13</b>	<b>15.82</b>	<b>15.7</b>	<b>16.11</b>
<b>Minimum</b>	<b>15.1</b>	<b>14.78</b>	<b>14.79</b>	<b>15.11</b>

It is evident from the data in Table No.32 that the average lactose content of control Peda (T<sub>0</sub>) was 15.61% and it ranged from 15.1% to 16.13%, while in the experimental Peda (T<sub>1</sub>) the average lactose content is 15.50% and it ranged from 14.78% to 15.82%. While in experimental Peda (T<sub>2</sub>) the average lactose content is 15.40% and it ranged from 14.79% to 15.70% in the experimental Peda (T<sub>3</sub>) the average lactose content is 15.61% and it ranged from 15.11% to 16.11%.

The above mentioned results have been shown in Figure No.12

### Average percentage of lactose in experimental and control Peda



[Figure.12]

Data shown in Table No.32 were further analyzed by analysis of variance techniques, results of this analysis is given in Table No. 33.

**Table No. 33.**

**Analysis of variance of average scores of lactose percentage of control and experimental.**

<b>Source of variation</b>	<b>D.F.</b>	<b>S.S.</b>	<b>M.S.S.</b>	<b>'F' Cal.</b>	<b>'F' Tab. (5%)</b>	<b>Result</b>
Due to replication	9	2.61	0.29	4.60	2.96	S
Due to treatments	3	0.41	0.136	2.15	2.96	N.S
Due to error	27	1.71	0.063			
<b>Total</b>	<b>39</b>	<b>4.73</b>				

It is evident from the results of ANOVA given in Table No.33, the variance ratio 2.15 is lower than the Table value of F (3.27) at 5% level of significance. This shows that there is no significant difference in lactose content in different treatment combination.

## PEDA

### Yield percentage

Table No: 34.

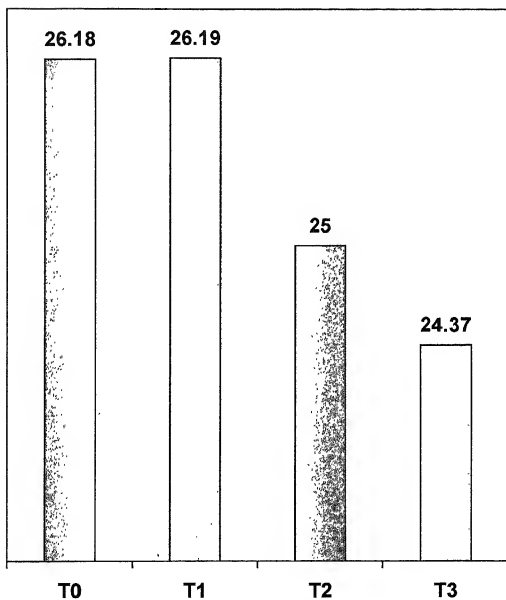
### Average Yield percentage in Experimental and Control Peda.

Sl. No.	T <sub>0</sub>	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>
1	25.6	25.4	24.8	24.4
2	26.0	25.9	24.5	24.0
3	25.7	26.4	25.3	24.8
4	26.2	26.4	25.1	24.7
5	25.4	26.0	24.7	24.5
6	26.4	25.8	24.9	24.7
7	26.7	26.4	25.3	23.8
8	26.5	26.7	25.1	23.9
9	26.9	26.4	24.9	24.7
10	26.4	26.5	25.4	24.2
<b>Average</b>	<b>26.18</b>	<b>26.19</b>	<b>25.00</b>	<b>24.37</b>
<b>Minimum</b>	<b>25.4</b>	<b>25.4</b>	<b>24.5</b>	<b>23.8</b>
<b>Maximum</b>	<b>26.9</b>	<b>26.7</b>	<b>25.4</b>	<b>24.8</b>

It is evident from the data in Table No 34 that the average yield of control Peda (T<sub>0</sub>) was 26.18% and it ranged from 25.4% to 26.9%, while in the experimental peda (T<sub>1</sub>) the average yield is 26.19% and it ranged from 25.4% to 26.7%. While in experimental Peda (T<sub>2</sub>) the average yield is 25.0% and it ranged from 24.5% to 25.4% in the experimental Peda (T<sub>3</sub>) the average yield is 24.37% and it ranged from 23.8% to 24.8%

The above mentioned results have been shown in Figure No.13.

### Average Yield percentage in Experimental and Control Peda



[Figure.13]

Data shown in Table No.34 were further analyzed by analysis of variance techniques, results of this analysis is given in Table No.35.

**Table No: 35.**

**Analysis of variance of average yield of control and experimental.**

Source of variation	D.F.	S.S.	M.S.S.	'F' Cal.	'F' Tab. (5%)	Result
Due to replication	9	2.11	0.235	1.80	2.96	N.S
Due to treatments	3	24.48	8.16	62.76	2.96	S
Due to error	27	3.51	0.13			
<b>Total</b>	39	30.11				

It is evident from the results of ANOVA given in Table no.35 the variance ratio 62.76 is greater than the Table value of F (3.27) at 5% level of significance. This shows that there is significant difference in yield of different treatment combination.

The significant differences thus obtained were further analyzed statistically to find out the C.D. between and within the different treatment combination of the data given in Table No 36.

**Table No: 36.****Critical differences in yield due to treatment combination of data.**

<b>Treatments</b>	<b>T<sub>0</sub> (26.18)</b>	<b>T<sub>1</sub>(26.19)</b>	<b>T<sub>2</sub>(25.0)</b>
<b>T<sub>3</sub>(24.37)</b>	1.81*	1.82*	0.63*
<b>T<sub>2</sub>(25.0)</b>	1.18*	1.19*	
<b>T<sub>1</sub>(26.19)</b>	0.01		

**C.D.=0.32****\*Significant at 5% level**

Table No 36, shows following variations in the yield of different treatment combinations.

Treatment T<sub>0</sub> & T<sub>1</sub> showed the difference (0.01), which is lower value than C.D. (0.32) therefore, the difference is non-significant

Treatment T<sub>0</sub> & T<sub>2</sub> showed the difference (1.18), which is lower than C.D. (0.32), therefore the difference is non-significant.

Treatment T<sub>0</sub> & T<sub>3</sub> showed the difference (1.81), which is higher than C.D. (0.32), therefore the difference is significant

Treatment T<sub>1</sub> & T<sub>2</sub> showed the difference (1.19), which is lower than C.D. (0.32), therefore the difference is non-significant.

Treatment T<sub>1</sub> & T<sub>3</sub> showed the difference (1.82), which is higher than C.D. (0.32), therefore the difference is significant.

Treatment T<sub>2</sub> & T<sub>3</sub> showed the difference (0.63), which is higher than C.D. (0.32), therefore the difference is significant.

# ORGANOLEPTIC EVALUATION

## PEDA

### Body and Texture

Table No: 37.

Average body and textures scores of experimental and control Peda.

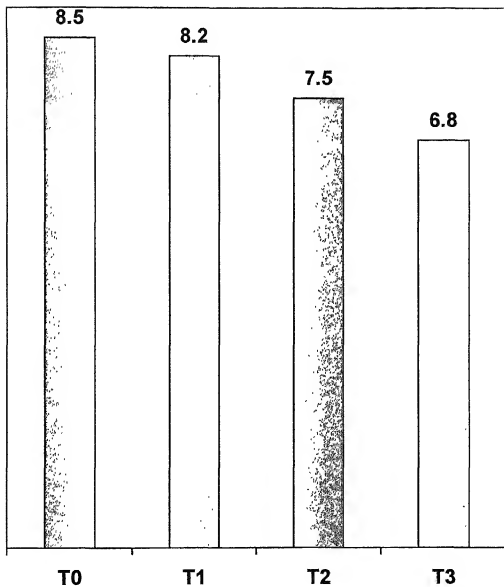
Sl. No.	T <sub>0</sub>	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>
1	8	8	7	7
2	9	8	7	7
3	8	8	8	6
4	9	9	7	7
5	9	8	7	7
6	9	9	8	6
7	8	8	8	7
8	8	8	7	8
9	9	8	8	6
10	8	8	8	7
Average	8.5	8.2	7.5	6.8
Maximum	9	9	8	8
Minimum	8	8	7	6

It is evident from the data in Table No.37 that the average body and texture scores of control Peda (T<sub>0</sub>) was 8.5% and it ranged from 8% to 9%, while in the experimental Peda (T<sub>1</sub>) the average body and texture scores is 8.2% and it ranged from 8% to 9%. While in experimental Peda (T<sub>2</sub>) the average body and texture scores is 7.5% and it ranged from 7% to 8% in the experimental Peda (T<sub>3</sub>) the average body and texture scores is 6.8% and it ranged from 6% to 8%.

The above mentioned results have been shown in Figure No.14



**Average body and textures scores  
of experimental and control Peda**



**[Figure.14]**

Data shown in Table No.37 were further analyzed by analysis of variance techniques, results of this analysis is given in Table no. 38.

**Table No. 38.**

**Analysis of variance of average scores of body and texture percentage of control and experimental.**

Source of variation	D.F.	S.S.	M.S.S.	'F' Cal.	'F' Tab. (5%)	Result
Due to replication	9	1.00	0.11	0.32	2.96	N.S
Due to treatments	3	17.3	5.76	16.93	2.96	S
Due to error	27	9.2	0.34			
<b>Total</b>	<b>39</b>	<b>27.5</b>				

It is evident from the results of ANOVA given in Table No.38, the variance ratio 16.93 is greater than the Table value of F (3,27) at 5% level of significance. This shows that there is significant difference in body and texture scores in different treatment combination.

The significant differences thus obtained were further analyzed statistically to find out the C.D. between and within the different treatment combination of the data given in Table No 39.

**Table No: 39.**

**Critical differences in body and texture scores due to treatment combination of data.**

<b>Treatments</b>	<b>T<sub>0</sub> (8.5)</b>	<b>T<sub>1</sub>(8.2)</b>	<b>T<sub>2</sub>(7.5)</b>
<b>T<sub>3</sub>(6.8)</b>	17*	14*	7*
<b>T<sub>2</sub>(7.5)</b>	10*	7*	
<b>T<sub>1</sub>(8.2)</b>	3*		

**C.D.=0.53**

**\*Significant at 5% level**

Table No 39, shows following variations in the body and texture scores of different treatment combinations.

Treatment T<sub>0</sub> & T<sub>1</sub> showed the difference (3), which is greater value than C.D. (0.53) therefore, the difference is significant.

Treatment T<sub>0</sub> & T<sub>2</sub> showed the difference (10), which is lower than C.D. (0.53), therefore the difference is significant.

Treatment T<sub>0</sub> & T<sub>3</sub> showed the difference (17), which is higher than C.D. (0.53), therefore the difference is significant

Treatment T<sub>1</sub> & T<sub>2</sub> showed the difference (7), which is lower than C.D. (0.53), therefore the difference is significant.

Treatment T<sub>1</sub> & T<sub>3</sub> showed the difference (14), which is higher than C.D. (0.53), therefore the difference is significant.

Treatment T<sub>2</sub> & T<sub>3</sub> showed the difference (7), which is higher than C.D. (0.53), therefore the difference is significant.

## PEDA

### Colour and appearance Scores

Table No: 40.

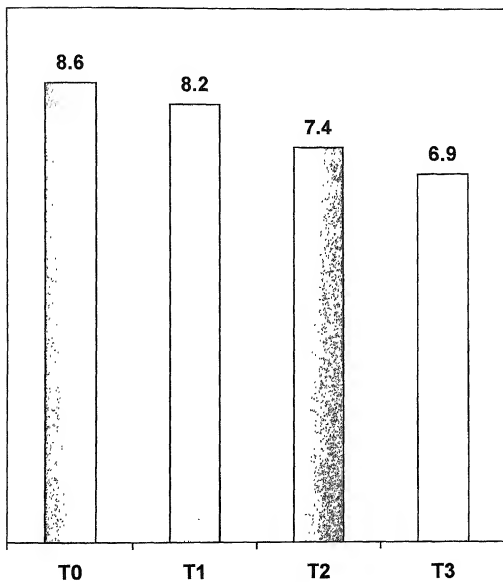
Average colour and appearance scores of control and experimental Peda.

Sl. No.	T <sub>0</sub>	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>
1	9	8	7	7
2	9	8	8	7
3	8	9	7	7
4	8	8	8	7
5	9	9	7	7
6	9	8	7	7
7	8	8	8	8
8	8	8	7	6
9	9	8	8	7
10	9	8	7	6
<b>Average</b>	<b>8.6</b>	<b>8.2</b>	<b>7.4</b>	<b>6.9</b>
<b>Maximum</b>	<b>9</b>	<b>9</b>	<b>8</b>	<b>8</b>
<b>Minimum</b>	<b>8</b>	<b>8</b>	<b>7</b>	<b>6</b>

It is evident from the data in Table No 40. that the average colour and appearance scores of control Peda (T<sub>0</sub>) was 8.6% and it ranged from 8% to 9%, while in the experimental peda (T<sub>1</sub>) the average colour and appearance scores is 8.2% and it ranged from 8% to 9%. While in experimental Peda (T<sub>2</sub>) the average colour and appearance scores is 7.4% and it ranged from 7% to 8% in the experimental Peda (T<sub>3</sub>) the average colour and appearance scores is 6.9% and it ranged from 6% to 8%.

The above mentioned results have been shown in Figure No.15

### Average colour and appearance scores of Peda



[Figure.15]

Data shown in Table No.40 were further analyzed by analysis of variance techniques, results of this analysis is given in Table no. 41.

**Table No.41.**

**Analysis of variance of average scores of colour and appearance of control and experimental Peda.**

Source of variation	D.F.	S.S.	M.S.S.	'F' Cal.	'F' Tab. (5%)	Result
Due to replication	9	2.22	0.24	0.94	2.96	N.S
Due to treatments	3	17.67	5.89	22.48	2.96	S
Due to error	27	7.07	0.26			
<b>Total</b>	<b>39</b>	<b>26.96</b>				

It is evident from the results of ANOVA given in Table no.41, the variance ratio 22.48 is greater than the Table value of F (3,27) at 5% level of significance. This shows that there is significant difference in colour and appearance scores in different treatment combination.

The significant differences thus obtained were further analyzed statistically to find out the C.D. between and within the different treatment combination of the data given in Table No 41.

**Table No: 42.**

**Critical differences in colour and appearance scores due to treatment combination of data.**

Treatments	T <sub>0</sub> (8.6)	T <sub>1</sub> (8.2)	T <sub>2</sub> (7.4)
T <sub>3</sub> (6.9)	17*	13*	6*
T <sub>2</sub> (7.4)	11*	8*	
T <sub>1</sub> (8.2)	4*		

**C.D.=0.46**

**\*Significant at 5% level**

Table No 42. shows following variations in the body and texture scores of different treatment combinations.

Treatment T<sub>0</sub> & T<sub>1</sub> showed the difference (4), which is greater value than C.D. (0.46) therefore, the difference is significant.

Treatment T<sub>0</sub> & T<sub>2</sub> showed the difference (11), which is lower than C.D. (0.46), therefore the difference is significant.

Treatment T<sub>0</sub> & T<sub>3</sub> showed the difference (17), which is higher than C.D. (0.46), therefore the difference is significant

Treatment T<sub>1</sub> & T<sub>2</sub> showed the difference (8), which is lower than C.D. (0.46), therefore the difference is significant.

Treatment T<sub>1</sub> & T<sub>3</sub> showed the difference (13), which is higher than C.D. (0.46), therefore the difference is significant.

Treatment T<sub>2</sub> & T<sub>3</sub> showed the difference (6), which is higher than C.D. (0.46), therefore the difference is significant

## PEDA

### Flavour scores

Table No: 43.

Average flavour scores of experimental and control Peda.

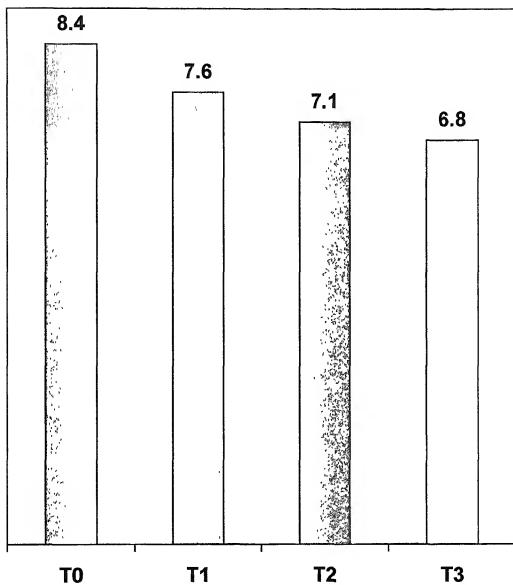
Sl. No.	T <sub>0</sub>	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>
1	8	8	7	7
2	9	7	6	6
3	8	7	7	6
4	8	8	8	7
5	9	7	7	7
6	8	7	8	8
7	8	8	7	7
8	8	8	7	7
9	9	8	7	6
10	9	8	7	7
Average	8.4	7.6	7.1	6.8
Maximum	9	8	8	8
Minimum	8	7	6	6

It is evident from the data in Table No 43. that the average flavour scores of control Peda (T<sub>0</sub>) was 8.4% and it ranged from 8% to 9%, while in the experimental Peda (T<sub>1</sub>) the average flavour scores is 7.6% and it ranged from 7% to 9%. While in experimental Peda (T<sub>2</sub>) the average flavour scores is 7.1% and it ranged from 6% to 8% in the experimental Peda (T<sub>3</sub>) the average flavour scores is 6.8% and it ranged from 6% to 8%.

The above mentioned results have been shown in Figure No.16.



### Average flavour scores of experimental and control Peda



[Figure.16]

Data shown in table No 43. were further analyzed by analysis of variance techniques, results of this analysis is given in Table No.44.

**Table No. 44.**

**Analysis of variance of average scores of flavour of control and experimental Peda.**

Source of variation	D.F.	S.S.	M.S.S.	'F' Cal.	'F' Tab. (5%)	Result
Due to replication	9	2.72	0.30	0.95	2.96	N.S
Due to treatments *	3	14.67	4.89	15.7	2.96	S
Due to error	27	8.57	0.31			
<b>Total</b>	39	23.97				

It is evident from the results of ANOVA given in Table No.44, the variance ratio 15.7 is greater than the Table value of F (3.27) at 5% level of significance. This shows that there is significant difference in flavour scores in different treatment combination.

The significant differences thus obtained were further analyzed statistically to find out the C.D. between and within the different treatment combination of the data given in Table No 45.

**Table No: 45.**

**Critical differences in flavour scores due to treatment combination of data.**

<b>Treatments</b>	<b>T<sub>0</sub> (8.6)</b>	<b>T<sub>1</sub>(8.2)</b>	<b>T<sub>2</sub>(7.4)</b>
<b>T<sub>3</sub>(6.9)</b>	<b>16*</b>	<b>8*</b>	<b>3*</b>
<b>T<sub>2</sub>(7.4)</b>	<b>13*</b>	<b>5*</b>	
<b>T<sub>1</sub>(8.2)</b>	<b>8*</b>		

**C.D.=0.51**

**\*Significant at 5% level**

Table No 45, shows following variations in the flavour scores of different treatment combinations.

Treatment T<sub>0</sub> & T<sub>1</sub> showed the difference (8), which is greater value than C.D. (0.51) therefore, the difference is significant.

Treatment T<sub>0</sub> & T<sub>2</sub> showed the difference (13), which is lower than C.D. (0.51), therefore the difference is significant.

Treatment T<sub>0</sub> & T<sub>3</sub> showed the difference (16), which is higher than C.D. (0.51), therefore the difference is significant

Treatment T<sub>1</sub> & T<sub>2</sub> showed the difference (5), which is lower than C.D. (0.51), therefore the difference is significant.

Treatment T<sub>1</sub> & T<sub>3</sub> showed the difference (8), which is higher than C.D. (0.51), therefore the difference is significant.

Treatment T<sub>2</sub> & T<sub>3</sub> showed the difference (3), which is higher than C.D. (0.51), therefore the difference is significant.

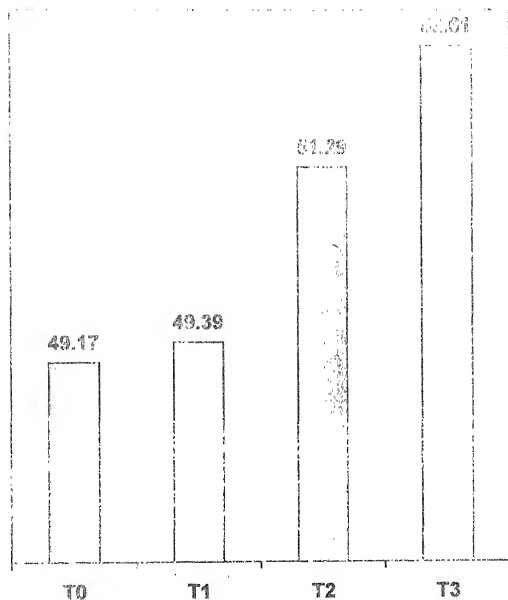
**Moisture Percentage****Table No: 46.****Average moisture percentage of control and experimental Chhana.**

<b>Sl. No.</b>	<b>T<sub>0</sub></b>	<b>T<sub>1</sub></b>	<b>T<sub>2</sub></b>	<b>T<sub>3</sub></b>
1	49.55	49.25	51.05	52.87
2	49.28	49.55	51.25	52.15
3	49.23	49.27	51.75	52.32
4	49.75	50.17	52.01	51.56
5	49.37	49.22	51.25	52.75
6	49.02	48.59	50.21	53.75
7	49.25	50.02	51.35	52.55
8	48.55	49.33	51.75	52.29
9	48.75	49.01	51.25	52.98
10	48.99	49.52	51.07	52.95
<b>Average</b>	<b>49.17</b>	<b>49.39</b>	<b>51.29</b>	<b>52.61</b>
<b>Maximum</b>	<b>49.75</b>	<b>50.17</b>	<b>52.01</b>	<b>53.75</b>
<b>Minimum</b>	<b>48.55</b>	<b>48.59</b>	<b>50.21</b>	<b>51.56</b>

Moisture percentage of control Chhana (T<sub>0</sub>) ranged from 48.55% to 49.75% with an average of 49.17%. Experimental Chhana (T<sub>1</sub>) had an average moisture percentage of 49.39% with a minimum of 48.59% and a maximum of 50.17%. Experimental Chhana (T<sub>2</sub>) had an average moisture percentage of 51.29% and it ranged from 50.21% to 52.01%. Experimental Chhana (T<sub>3</sub>) had an average of 52.61% with a minimum of 51.56% and a maximum of 53.75%.

The above-mentioned results have been shown in Figure No 17.

# Effect of Pesticides on the Growth of *Chironomus* in the Laboratory and in the Field



[Figure.17]

Data shown in Table No.46 were further analyzed by analysis of variance techniques, results of this analysis is given in Table no.47.

**Table No. 47.**

**Analysis of variance of average scores of moisture percentage of control and experimental Chhana.**

Source of variation	D.F.	S.S.	M.S.S.	'F' Cal.	'F' Tab. (5%)	Result
Due to replication	9	0.75	0.083	0.31	2.96	S
Due to treatments	3	80.38	26.79	101.86	2.96	S
Due to error	27	7.72	0.263			
<b>Total</b>	<b>39</b>	<b>88.85</b>				

It is evident from the result of ANOVA given in the Table No 47, the variance ratio of 101.86 is greater than the Table value of F (3.27) at 5% level of significance. This indicates that there were significant differences in different treatment combination  $T_0$ ,  $T_1$ ,  $T_2$ , &  $T_3$ . It is concluded that there is significant difference in the moisture percentage of different treatment combination.

The significant differences thus obtained were further analyzed statistically to find out the C.D. between and within the different combinations of controlled and filled chhana Results of C.D. are presented in Table No 48.

**Table: 48.**

**Critical differences in Moisture percentage due to treatment combination of data.**

<b>Treatments</b>	<b>T<sub>0</sub> (49.17)</b>	<b>T<sub>1</sub>(49.39)</b>	<b>T<sub>2</sub>(51.29)</b>
<b>T<sub>3</sub>(52.61)</b>	3.44*	3.22*	1.32*
<b>T<sub>2</sub>(51.29)</b>	2.12*	1.90*	
<b>T<sub>1</sub>(49.39)</b>	0.22		

**C.D.=0.23**

**\*Significant at 5% level**

Table No 48, shows following variations in the Moisture percentage of different treatment combinations.

The difference in mean value of T<sub>0</sub> & T<sub>1</sub> (0.22) is lower than the C.D. (0.23), therefore the difference is non-significant.

The difference in mean value between T<sub>0</sub> & T<sub>2</sub> (2.12) is higher than the C.D. (0.23), therefore the difference is significant.

The difference in mean value of T<sub>0</sub> & T<sub>3</sub> (3.44) is higher than the C.D. (0.23), therefore the difference is significant.

The difference in mean value of T<sub>1</sub> & T<sub>2</sub> (1.90) is higher than the C.D. (0.23), therefore the difference is significant.

The difference in mean value of T<sub>1</sub> & T<sub>3</sub> (3.22) is higher than the C.D. (0.23), therefore the difference is significant.

The difference in mean value of T<sub>2</sub> & T<sub>3</sub> (1.32) is higher than the C.D. (0.23), therefore the difference is significant.

## CHHANA

### Fat Percentage

**Table No: 49.**

**Average fat percentage in experimental and control Chhana.**

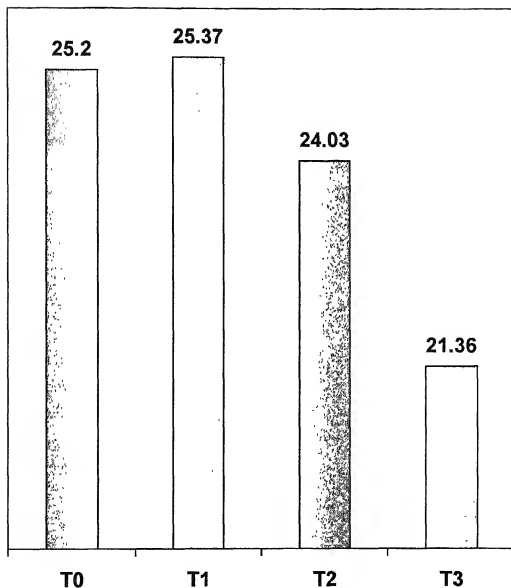
SL No.	T <sub>0</sub>	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>
1	25.25	25.65	24.2	21.43
2	25.75	24.75	23.52	21.35
3	25.32	25.25	24.17	21.52
4	24.55	25.95	23.35	21.1
5	25.21	25.17	25.21	20.95
6	25.37	24.95	23.39	21.35
7	25.75	25.5	24.56	21.75
8	25.22	25.75	23.95	21.55
9	25.31	25.42	24.06	21.43
10	24.35	25.32	24.22	21.21
<b>Average</b>	<b>25.2</b>	<b>25.37</b>	<b>24.03</b>	<b>21.36</b>
<b>Maximum</b>	<b>25.75</b>	<b>25.95</b>	<b>25.21</b>	<b>21.75</b>
<b>Minimum</b>	<b>24.35</b>	<b>24.75</b>	<b>23.35</b>	<b>20.95</b>

Fat percentage of control Chhana (T<sub>0</sub>) ranged from 24.35% to 25.75% with an average of 25.20%. Experimental Chhana (T<sub>1</sub>) had an average fat percentage of 25.32% with a minimum of 24.75% and a maximum of 25.95%. Experimental Chhana (T<sub>2</sub>) had an average fat percentage of 24.03% and it ranged from 23.35% to 25.21%. Experimental Chhana (T<sub>3</sub>) had an average fat percentage of 21.36% with a minimum of 20.95% and a maximum of 21.75%.

The above mentioned results have been shown in Figure No.18.



**Average fat percentage in  
experimental and control Chhana**



**[Figure.18]**

Data shown in Table No.49 were further analyzed by analysis of variance techniques, results of this analysis is given in Table No. 50.

**Table No. 50.**

**Analysis of variance of average scores of Fat percentage of control and experimental Chhana.**

Source of variation	D.F.	S.S.	M.S.S.	'F' Cal.	'F' Tab. (5%)	Result
Due to replication	9	1.62	0.180	1.02	2.96	S
Due to treatments	3	102.91	34.30	197.72	2.96	S
Due to error	27	4.76	0.176			
<b>Total</b>	<b>39</b>	<b>109.29</b>				

It is evident from the result of ANOVA given in the Table No 50. the variance ratio of 197.72 is greater than the Table value of F (3,27) at 5% level of significance. This indicates that there were significant differences in different treatment combination T<sub>0</sub>, T<sub>1</sub>, T<sub>2</sub>, & T<sub>3</sub>. It is concluded that there is significant difference in the fat percentage of different treatment combination.

The significant differences thus obtained were further analyzed statistically to find out the C.D. between and within the different combinations of controlled and filled chhana. Results of C.D. are presented in Table No 51.

**Table No: 51.**

**Critical differences in Fat percentage due to treatment combination of data.**

Treatments	T <sub>0</sub> (25.20)	T <sub>1</sub> (25.37)	T <sub>2</sub> (24.06)
T <sub>3</sub> (21.36)	3.84*	4.01*	3.00*
T <sub>2</sub> (24.06)	0.84*	1.01*	
T <sub>1</sub> (25.37)	0.17		

**C.D.=0.38**

**\*Significant at 5% level**

Table No 51 shows following variations in the Fat percentage of different treatment combinations.

The difference in mean value of T<sub>0</sub> & T<sub>1</sub> (0.17) is lower than the C.D. (0.38), therefore the difference is non-significant.

The difference in mean value between T<sub>0</sub> & T<sub>2</sub> (0.84) is higher than the C.D. (0.38), therefore the difference is significant.

The difference in mean value of T<sub>0</sub> & T<sub>3</sub> (3.84) is higher than the C.D. (0.38), therefore the difference is significant.

The difference in mean value of T<sub>1</sub> & T<sub>2</sub> (1.01) is higher than the C.D. (0.38), therefore the difference is significant.

The difference in mean value of T<sub>1</sub> & T<sub>3</sub> (4.01) is higher than the C.D. (0.38), therefore the difference is significant.

The difference in mean value of T<sub>2</sub> & T<sub>3</sub> (3.00) is higher than the C.D. (0.38), therefore the difference is significant.

## CHHANA

### Protein Percentage

Table No: 52.

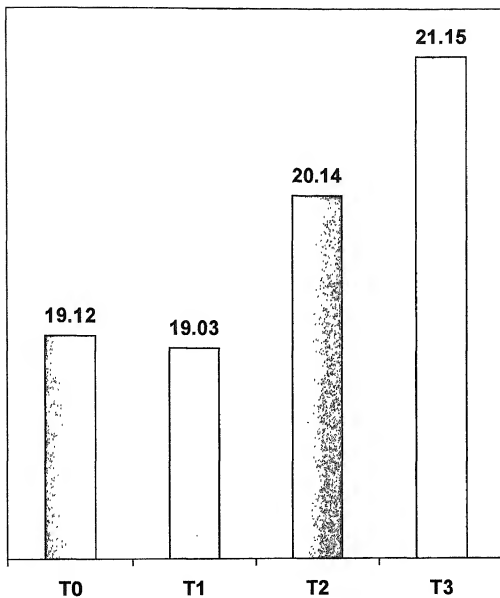
Average protein percentage in Experimental and control Chhana.

Sl. No.	T <sub>0</sub>	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>
1	19.07	19.12	20.45	21.43
2	19.09	18.86	19.94	20.86
3	19.14	19.05	20.12	21.16
4	18.75	18.72	20.02	20.96
5	19.21	19.2	20.35	21.25
6	19.19	19.35	20.42	21.45
7	19.24	18.78	20.1	21.08
8	19.44	19.15	19.92	20.98
9	18.88	18.82	19.86	21.02
10	19.23	19.26	20.28	21.35
<b>Average</b>	<b>19.12</b>	<b>19.03</b>	<b>20.14</b>	<b>21.15</b>
<b>Maximum</b>	<b>19.44</b>	<b>19.35</b>	<b>20.45</b>	<b>21.45</b>
<b>Minimum</b>	<b>18.75</b>	<b>18.72</b>	<b>19.86</b>	<b>20.86</b>

Protein percentage of control Chhana (T<sub>0</sub>) ranged from 18.75% to 19.44% with an average of 19.12%. Experimental Chhana (T<sub>1</sub>) had an average protein percentage of 19.03% with a minimum of 18.72% and a maximum of 19.35%. Experimental Chhana (T<sub>2</sub>) had an average protein percentage of 20.14% and it ranged from 19.86 % to 20.45%. Experimental Chhana (T<sub>3</sub>) had an average protein percentage of 21.15% with a minimum of 20.86% and a maximum of 21.45%.

The above mentioned results have been shown in Figure No.19

**Average protein percentage in  
Experimental and control Chhana**



**[Figure.19]**

Data shown in Table No.52 were further analyzed by analysis of variance techniques, results of this analysis is given in Table No. 53

**Table No. 53.**

**Analysis of variance of average scores of protein percentage of control and experimental Chhana.**

Source of variation	D.F.	S.S.	M.S.S.	'F' Cal.	'F' Tab. (5%)	Result
Due to replication	9	1.09	0.121	6.72	2.96	S
Due to treatments	3	29.85	9.95	552.77	2.96	S
Due to error	27	0.50	0.018			
<b>Total</b>	<b>39</b>	<b>31.44</b>				

It is evident from the result of ANOVA given in the Table No 53 the variance ratio of 552.77 is greater than the Table value of F (3.27) at 5% level of significance. This indicates that there were significant differences in different treatment combination T<sub>0</sub>, T<sub>1</sub>, T<sub>2</sub>, & T<sub>3</sub>. It is concluded that there is significant difference in the protein percentage of different treatment combination.

The significant differences thus obtained were further analyzed statistically to find out the C.D. between and within the different combinations of controlled and filled chhana. Results of C.D. are presented in Table No 54.

**Table No: 54.**

**Critical differences in protein percentage due to treatment combination of data given in.**

<b>Treatments</b>	<b>T<sub>0</sub> (19.12)</b>	<b>T<sub>1</sub>(25.37)</b>	<b>T<sub>2</sub>(24.06)</b>
<b>T<sub>3</sub>(21.15)</b>	2.03*	2.12*	1.01*
<b>T<sub>2</sub>(20.14)</b>	1.02*	1.11*	
<b>T<sub>1</sub>(19.03)</b>	0.09		

**C.D.=0.123**

**\*Significant at 5% level**

Table No 54 shows following variations in the protein percentage of different treatment combinations.

The difference in mean value of T<sub>0</sub> & T<sub>1</sub> (0.09) is lower than the C.D. (0.123), therefore the difference is non-significant.

The difference in mean value between T<sub>0</sub> & T<sub>2</sub> (1.02) is higher than the C.D. (0.123), therefore the difference is significant.

The difference in mean value of T<sub>0</sub> & T<sub>3</sub> (2.03) is higher than the C.D. (0.123), therefore the difference is significant.

The difference in mean value of T<sub>1</sub> & T<sub>2</sub> (1.11) is higher than the C.D. (0.123), therefore the difference is significant.

The difference in mean value of T<sub>1</sub> & T<sub>3</sub> (2.12) is higher than the C.D. (0.123), therefore the difference is significant.

The difference in mean value of T<sub>2</sub> & T<sub>3</sub> (1.01) is higher than the C.D. (0.123), therefore the difference is significant.

## CHHANA

### Yield Percentage

Table No: 55.

Averages yield percentage in Experimental and control Chhana.

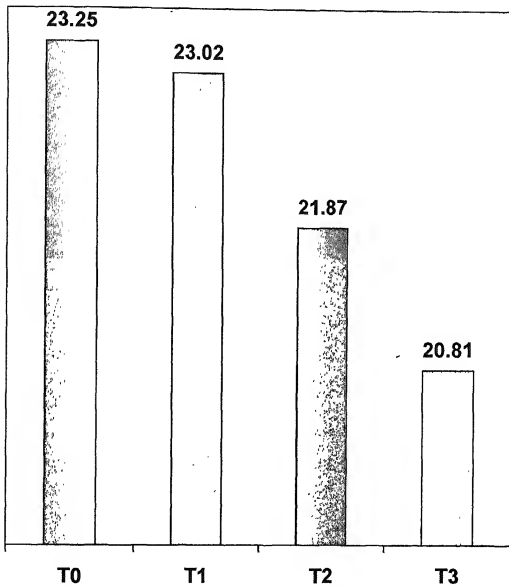
Sl. No.	T <sub>0</sub>	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>
1	23.00	22.10	21.30	20.00
2	22.70	23.20	21.50	20.00
3	22.60	23.20	22.10	21.10
4	23.10	22.70	22.10	20.90
5	23.50	23.20	21.80	20.50
6	22.90	22.30	21.30	20.30
7	23.30	23.00	21.70	21.50
8	23.50	23.70	22.50	21.60
9	23.70	23.20	21.90	21.10
10	24.20	23.60	22.50	21.10
<b>Average</b>	<b>23.25</b>	<b>23.02</b>	<b>21.87</b>	<b>20.81</b>
<b>Minimum</b>	<b>22.60</b>	<b>22.10</b>	<b>21.30</b>	<b>20.00</b>
<b>Maximum</b>	<b>24.20</b>	<b>23.70</b>	<b>22.50</b>	<b>21.60</b>

Yield percentage of control Chhana (T<sub>0</sub>) ranged from 24.20% to 22.60% with an average of 23.25%. Experimental Chhana (T<sub>1</sub>) had an average yield percentage of 23.0% with a minimum of 22.10% and a maximum of 23.70%. Experimental Chhana (T<sub>2</sub>) had an average yield percentage of 21.87% and it ranged from 21.30% to 22.50%. Experimental Chhana (T<sub>3</sub>) had an average yield percentage of 20.81% with a minimum of 20.00% and a maximum of 21.60%.

The above mentioned results have been shown in Figure No.20.



# Averages yield percentage in Experimental and control Chhana



[Figure.20]

Data shown in Table No.55 were further analyzed by analysis of variance techniques, results of this analysis is given in Table No. 56.

**Table No. 56.**

**Analysis of variance of average scores of yield percentage of control and experimental Chhana.**

Source of variation	D.F.	S.S.	M.S.S.	'F' Cal.	'F' Tab. (5%)	Result
Due to replication	9	6.57	0.73	7.20	2.96	S
Due to treatments	3	38.10	12.70	125.00	2.96	S
Due to error	27	2.73	0.10			
<b>Total</b>	<b>39</b>	<b>47.41</b>				

It is evident from the result of ANOVA given in the Table No 56 the variance ratio of 125.00 is greater than the Table value of F (3.27) at 5% level of significance. This indicates that there were significant differences in different treatment combination  $T_0$ ,  $T_1$ ,  $T_2$ , &  $T_3$ . It is concluded that there is significant difference in the protein percentage of different treatment combination.

The significant differences thus obtained were further analyzed statistically to find out the C.D. between and within the different combinations of controlled and filled chhana. Results of C.D. are presented in Table No 57.

**Table No: 57.**

**Critical differences in yield percentage due to treatment combination of data given in.**

Treatments	T <sub>0</sub> (23.25)	T <sub>1</sub> (23.02)	T <sub>2</sub> (21.87)
T <sub>3</sub> (20.81)	2.44*	2.21*	1.06*
T <sub>2</sub> (21.87)	1.38*	1.15*	
T <sub>1</sub> (23.02)	0.23		

**C.D.=2.91**

**\*Significant at 5% level**

Table No 57. shows following variations in the yield percentage of different treatment combinations.

The difference in mean value of T<sub>0</sub> & T<sub>1</sub> (0.23) is lower than the C.D. (2.91), therefore the difference is non-significant.

The difference in mean value between T<sub>0</sub> & T<sub>2</sub> (1.38) is higher than the C.D. (2.91), therefore the difference is significant.

The difference in mean value of T<sub>0</sub> & T<sub>3</sub> (2.44) is higher than the C.D. (2.91), therefore the difference is significant.

The difference in mean value of T<sub>1</sub> & T<sub>2</sub> (1.15) is higher than the C.D. (2.91), therefore the difference is significant.

The difference in mean value of T<sub>1</sub> & T<sub>3</sub> (2.21) is higher than the C.D. (2.91), therefore the difference is significant.

The difference in mean value of T<sub>2</sub> & T<sub>3</sub> (1.06) is higher than the C.D. (2.91), therefore the difference is significant.

## SANDESH

### Moisture percentage

Table No: 58.

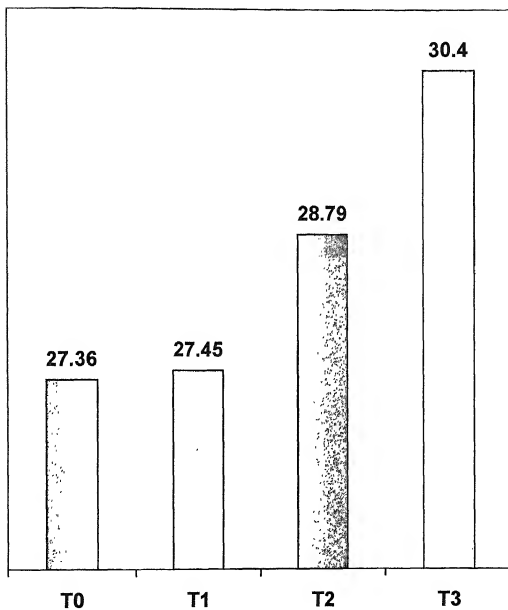
Average moisture percentage in Experimental and Control Sandesh.

Sl. No.	T <sub>0</sub>	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>
1	27.52	27.58	28.88	30.65
2	27.45	27.21	28.98	30.52
3	27.35	27.75	29.12	30.75
4	27.21	27.62	29.01	30.92
5	27.53	27.41	28.53	30.45
6	27.05	27.35	28.61	30.21
7	27.56	27.92	28.52	29.95
8	27.33	27.11	28.75	29.52
9	27.31	27.22	29	30.55
10	27.35	27.37	28.51	30.52
Average	27.36	27.45	28.79	30.4
Maximum	27.56	27.92	29.12	30.92
Minimum	27.05	27.11	28.51	29.52

Moisture percentage of control Sandesh (T<sub>0</sub>) ranged from 27.05% to 27.56% with an average of 27.36%. Experimental Sandesh (T<sub>1</sub>) had an average moisture percentage of 27.45% with a minimum of 27.11% and a maximum of 27.92%. Experimental Sandesh (T<sub>2</sub>) had an average moisture percentage of 28.79% and it ranged from 28.51% to 29.12%. Experimental Sandesh (T<sub>3</sub>) had an average Sandesh percentage of 30.40% with a minimum of 29.52% and a maximum of 30.92%.

The above mentioned results have been shown in Figure No.21.

**Average moisture percentage in  
Experimental and Control Sandesh**



**[Figure.21]**

Data shown in Table No.58 were further analyzed by analysis of variance techniques, results of this analysis is given in Table No.59.

**Table No. 59.**

**Analysis of variance of average scores of moisture percentage of control and experimental Sandesh.**

Source of variation	D.F.	S.S.	M.S.S.	'F' Cal.	'F' Tab. (5%)	Result
Due to replication	9	1.067	.118	0.86	2.96	S
Due to treatments	3	59.68	19.89	144.97	2.96	S
Due to error	27	3.70	0.137			
<b>Total</b>	<b>39</b>	<b>64.43</b>				

It is evident from the result of ANOVA given in the Table No 59 the variance ratio of 144.97 is greater than the Table value of F (3.27) at 5% level of significance. This indicates that there were significant differences in different treatment combination  $T_0$ ,  $T_1$ ,  $T_2$ , &  $T_3$ . It is concluded that there is significant difference in the moisture percentage of different treatment combination.

The significant differences thus obtained were further analyzed statistically to find out the C.D. between and within the different combinations of controlled and filled Sandesh. Results of C.D. are presented in Table No 60..

**Table No: 60.**

**Critical differences in moisture percentage due to treatment combination of data.**

Treatments	T <sub>0</sub> (27.36)	T <sub>1</sub> (27.45)	T <sub>2</sub> (28.70)
T <sub>3</sub> (30.40)	2.03*	2.12*	1.01*
T <sub>2</sub> (28.70)	1.02*	1.11*	
T <sub>1</sub> (27.45)	0.09		

**C.D.=0.33**

**\*Significant at 5% level**

Table No 60 shows following variations in the moisture percentage of different treatment combinations.

The difference in mean value of T<sub>0</sub> & T<sub>1</sub> (0.09) is lower than the C.D. (0.33), therefore the difference is non-significant.

The difference in mean value between T<sub>0</sub> & T<sub>2</sub> (1.02) is higher than the C.D. (0.33), therefore the difference is significant.

The difference in mean value of T<sub>0</sub> & T<sub>3</sub> (2.03) is higher than the C.D. (0.33), therefore the difference is significant.

The difference in mean value of T<sub>1</sub> & T<sub>2</sub> (1.11) is higher than the C.D. (0.33), therefore the difference is significant.

The difference in mean value of T<sub>1</sub> & T<sub>3</sub> (2.12) is higher than the C.D. (0.33), therefore the difference is significant.

The difference in mean value of T<sub>2</sub> & T<sub>3</sub> (1.01) is higher than the C.D. (0.33), therefore the difference is significant

## SANDESH

### Fat percentage

Table No: 61.

Average fat percentage of experimental and control Sandesh.

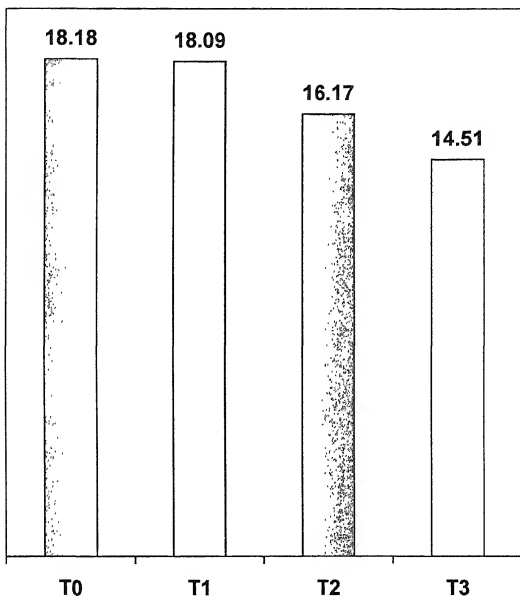
Sl. No.	T <sub>0</sub>	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>
1	18.35	18.12	16.17	14.78
2	18.17	18.33	16.22	14.52
3	18.31	18.43	16.05	14.81
4	18.31	18.39	16.35	14.35
5	18.92	18.02	15.92	14.29
6	18.11	17.92	16.15	14.92
7	18.17	17.75	16.35	14.09
8	17.56	18.32	16.25	13.92
9	17.72	17.59	16.21	14.92
10	18.25	18.11	16.09	14.57
Average	18.18	18.09	16.17	14.51
Maximum	18.92	18.43	16.35	14.92
Minimum	17.56	17.59	15.92	13.92

Fat percentage of control Sandesh (T<sub>0</sub>) ranged from 17.56% to 18.92% with an average of 18.18%. Experimental Sandesh (T<sub>1</sub>) had an average fat percentage of 18.09% with a minimum of 17.59% and a maximum of 18.43%. Experimental Sandesh (T<sub>2</sub>) had an average fat percentage of 16.17% and it ranged from 15.92% to 16.35%. Experimental Sandesh (T<sub>3</sub>) had an average fat percentage of 14.51% with a minimum of 13.92% and a maximum of 14.92%.

The above mentioned results have been shown in Figure No.22.



**Average fat percentage of experimental  
and control Sandesh**



**[Figure.22]**

Data shown in Table No.61 were further analyzed by analysis of variance techniques, results of this analysis is given in Table No.62.

**Table No. 62.**

**Analysis of variance of average scores of fat percentage of control and experimental Sandesh.**

Source of variation	D.F.	S.S.	M.S.S.	'F' Cal.	'F' Tab. (5%)	Result
Due to replication	9	0.60	0.066	0.277	2.96	S
Due to treatments	3	91.97	30.65	123.61	2.96	S
Due to error	27	6.59	0.244			
<b>Total</b>	<b>39</b>	<b>99.16</b>				

It is evident from the result of ANOVA given in the Table No 62 the variance ratio of 123.61 is greater than the Table value of F (3.27) at 5% level of significance. This indicates that there were significant differences in different treatment combination T<sub>0</sub>, T<sub>1</sub>, T<sub>2</sub>, & T<sub>3</sub>. It is concluded that there is significant difference in the fat percentage of different treatment combination.

The significant differences thus obtained were further analyzed statistically to find out the C.D. between and within the different combinations of controlled and filled sandesh. Results of C.D. are presented in Table No 63.

**Table No: 63.**

**Critical differences in fat percentage due to treatment combination of data.**

<b>Treatments</b>	<b>T<sub>0</sub>(18.18)</b>	<b>T<sub>1</sub>(18.09)</b>	<b>T<sub>2</sub>(16.17)</b>
<b>T<sub>3</sub>(14.51)</b>	2.03*	2.12*	1.01*
<b>T<sub>2</sub>(16.17)</b>	1.02*	1.11*	
<b>T<sub>1</sub>(18.09)</b>	0.09		

**C.D.=0.43**

**\*Significant at 5% level**

Table No 63. shows following variations in the moisture percentage of different treatment combinations.

The difference in mean value of T<sub>0</sub> & T<sub>1</sub> (0.09) is lower than the C.D. (0.43), therefore the difference is non-significant.

The difference in mean value between T<sub>0</sub> & T<sub>2</sub> (1.02) is higher than the C.D. (0.43), therefore the difference is significant.

The difference in mean value of T<sub>0</sub> & T<sub>3</sub> (2.03) is higher than the C.D. (0.43), therefore the difference is significant.

The difference in mean value of T<sub>1</sub> & T<sub>2</sub> (1.11) is higher than the C.D. (0.43), therefore the difference is significant.

The difference in mean value of T<sub>1</sub> & T<sub>3</sub> (2.12) is higher than the C.D. (0.43), therefore the difference is significant.

The difference in mean value of T<sub>2</sub> & T<sub>3</sub> (1.01) is higher than the C.D. (0.43), therefore the difference is significant.

## SANDESH

### Protein percentage

Table No: 64.

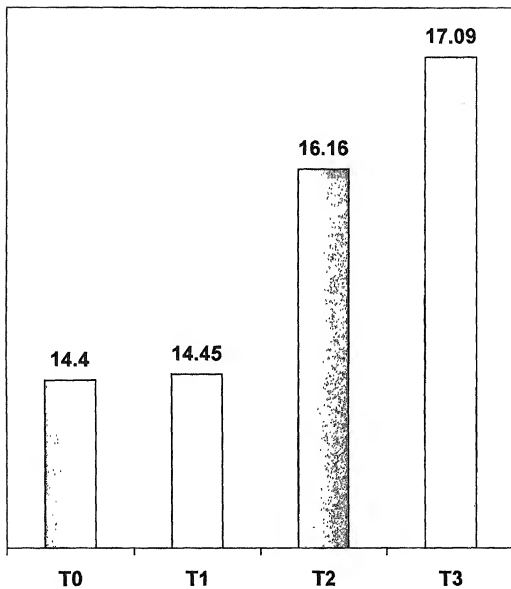
Average protein percentage of experimental and control Sandesh.

Sl. No.	T <sub>0</sub>	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>
1	14.55	14.78	16.11	17.02
2	14.72	14.52	16.32	17.12
3	14.37	14.33	16.21	16.92
4	14.88	14.92	16.52	16.75
5	14.75	14.89	16.12	17.35
6	14.35	14.11	15.92	17.25
7	14.11	13.92	15.75	16.88
8	13.93	14.35	15.89	17.25
9	13.89	14.52	16.45	17.11
10	14.45	14.22	16.37	17.25
<b>Average</b>	<b>14.4</b>	<b>14.45</b>	<b>16.16</b>	<b>17.09</b>
<b>Maximum</b>	<b>14.88</b>	<b>14.92</b>	<b>16.52</b>	<b>17.35</b>
<b>Minimum</b>	<b>13.89</b>	<b>13.92</b>	<b>15.75</b>	<b>16.75</b>

Protein percentage of control Sandesh (T<sub>0</sub>) ranged from 13.89% to 14.88% with an average of 14.40%. Experimental Sandesh (T<sub>1</sub>) had an average protein percentage of 14.45% with a minimum of 13.92% and a maximum of 14.92%. Experimental sandesh (T<sub>2</sub>) had an average protein percentage of 16.16% and it ranged from 15.75% to 16.52%. Experimental sandesh (T<sub>3</sub>) had an average protein percentage of 17.09% with a minimum of 16.75% and a maximum of 17.35%.

The above mentioned results have been shown in Figure No.23.

**Average protein percentage of  
experimental and control Sandesh**



**[Figure.23]**

Data shown in Table No.64 were further analyzed by analysis of variance techniques, results of this analysis is given in Table no.65.

**Table No. 65.**

**Analysis of variance of average scores of protein percentage of control and experimental Sandesh.**

Source of variation	D.F.	S.S.	M.S.S.	'F' Cal.	'F' Tab. (5%)	Result
Due to replication	9	1.31	0.14	2.29	2.96	S
Due to treatments	3	52.68	17.56	287	2.96	S
Due to error	27	1.67	0.061			
<b>Total</b>	<b>39</b>	<b>55.66</b>				

It is evident from the result of ANOVA given in the Table No 65 the variance ratio of 287 is greater than the Table value of F (3.27) at 5% level of significance. This indicates that there were significant differences in different treatment combination  $T_0$ ,  $T_1$ ,  $T_2$ , &  $T_3$ . It is concluded that there is significant difference in the protein percentage of different treatment combination.

The significant differences thus obtained were further analyzed statistically to find out the C.D. between and within the different combinations of controlled and filled sandesh. Results of C.D. are presented in Table No 66.

**Table No: 66.**

**Critical differences in protein percentage due to treatment combination of data.**

<b>Treatments</b>	<b>T<sub>0</sub> (14.40)</b>	<b>T<sub>1</sub>(14.45)</b>	<b>T<sub>2</sub>(16.16)</b>
<b>T<sub>3</sub>(17.09)</b>	2.69*	2.64*	0.93*
<b>T<sub>2</sub>(16.16)</b>	1.76*	1.71*	
<b>T<sub>1</sub>(14.45)</b>	0.05		

**C.D.=0.23**

**\*Significant at 5% level**

Table No 66 shows following variations in the moisture percentage of different treatment combinations.

The difference in mean value of T<sub>0</sub> & T<sub>1</sub> (0.05) is lower than the C.D. (0.23), therefore the difference is non-significant.

The difference in mean value between T<sub>0</sub> & T<sub>2</sub> (1.76) is higher than the C.D. (0.23), therefore the difference is significant.

The difference in mean value of T<sub>0</sub> & T<sub>3</sub> (2.69) is higher than the C.D. (0.23), therefore the difference is significant.

The difference in mean value of T<sub>1</sub> & T<sub>2</sub> (1.71) is higher than the C.D. (0.23), therefore the difference is significant.

The difference in mean value of T<sub>1</sub> & T<sub>3</sub> (2.64) is higher than the C.D. (0.23), therefore the difference is significant.

The difference in mean value of T<sub>2</sub> & T<sub>3</sub> (0.93) is higher than the C.D. (0.23), therefore the difference is significant.

## SANDESH

**Total sugar percentage**

**Table No: 67.**

**Average total sugar percentage in experimental and control Sandesh.**

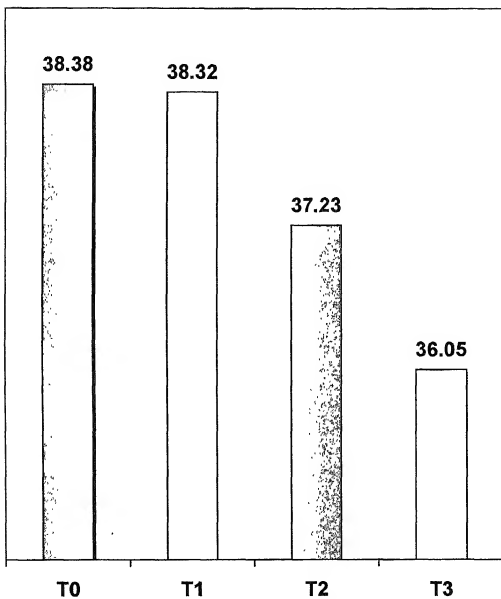
SL No.	T <sub>0</sub>	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>
1	38.13	37.79	36.97	35.6
2	37.91	38.32	36.73	35.88
3	38.32	37.76	36.79	35.59
4	37.98	37.66	36.27	36.09
5	37.22	38.15	37.54	36.03
6	38.82	38.93	37.61	35.65
7	38.43	38.7	37.45	37.07
8	39.51	38.58	37.88	37.46
9	39.39	38.95	36.62	35.45
10	38.13	38.43	38.49	35.68
<b>Average</b>	<b>38.38</b>	<b>38.32</b>	<b>37.23</b>	<b>36.05</b>
<b>Maximum</b>	<b>39.51</b>	<b>38.93</b>	<b>38.49</b>	<b>37.46</b>
<b>Minimum</b>	<b>37.22</b>	<b>37.76</b>	<b>36.27</b>	<b>35.45</b>

Total sugar percentage of control Sandesh (T<sub>0</sub>) ranged from 37.22% to 39.51% with an average of 38.38%. Experimental Sandesh (T<sub>1</sub>) had an average total sugar percentage of 38.32% with a minimum of 37.76% and a maximum of 38.93%. Experimental sandesh (T<sub>2</sub>) had an average total sugar percentage of 37.23% and it ranged from 36.27% to 38.49%. Experimental sandesh (T<sub>3</sub>) had an average total sugar percentage of 36.05% with a minimum of 35.45% and a maximum of 37.46%.

The above mentioned results have been shown in Figure No.24.



### Average total sugar percentage in experimental and control Sandesh



[Figure.24]

Data shown in Table No.67 were further analyzed by analysis of variance techniques, results of this analysis is given in Table No. 68.

**Table No. 68.**

**Analysis of variance of average scores of Total sugar percentage of control and experimental Sandesh.**

Source of variation	D.F.	S.S.	M.S.S.	'F' Cal.	'F' Tab. (5%)	Result
Due to replication	9	6.82	0.75	1.40	2.96	S
Due to treatments	3	29.17	9.72	17.95	2.96	S
Due to error	27	14.62	0.54			
<b>Total</b>	39	50.62				

It is evident from the result of ANOVA given in the Table No 67 the variance ratio of 17.95 is greater than the Table value of F (3.27) at 5% level of significance. This indicates that there were significant differences in different treatment combination  $T_0$ ,  $T_1$ ,  $T_2$ , &  $T_3$ . It is concluded that there is significant difference in the Total sugar percentage of different treatment combination.

The significant differences thus obtained were further analyzed statistically to find out the C.D. between and within the different combinations of controlled and filled Sandesh. Results of C.D. are presented in Table No 69.

**Table No: 69.**

**Critical differences in Total sugar percentage due to treatment combination of data.**

Treatments	T <sub>0</sub> (38.84)	T <sub>1</sub> (38.32)	T <sub>2</sub> (37.23)
T <sub>3</sub> (36.04)	2.34*	2.28*	1.19*
T <sub>2</sub> (37.23)	1.15*	1.09*	
T <sub>1</sub> (38.32)	0.06		

**C.D.=0.67**

**\*Significant at 5% level**

Table No 69 shows following variations in the moisture percentage of different treatment combinations.

The difference in mean value of T<sub>0</sub> & T<sub>1</sub> (0.06) is lower than the C.D. (0.67), therefore the difference is non-significant.

The difference in mean value between T<sub>0</sub> & T<sub>2</sub> (1.15) is higher than the C.D. (0.67), therefore the difference is significant.

The difference in mean value of T<sub>0</sub> & T<sub>3</sub> (2.34) is higher than the C.D. (0.67), therefore the difference is significant.

The difference in mean value of T<sub>1</sub> & T<sub>2</sub> (1.09) is higher than the C.D. (0.67), therefore the difference is significant.

The difference in mean value of T<sub>1</sub> & T<sub>3</sub> (2.28) is higher than the C.D. (0.67), therefore the difference is significant.

The difference in mean value of T<sub>2</sub> & T<sub>3</sub> (1.19) is higher than the C.D. (0.67), therefore the difference is significant.

## SANDESH

### - Free fat percentage

Table No: 70.

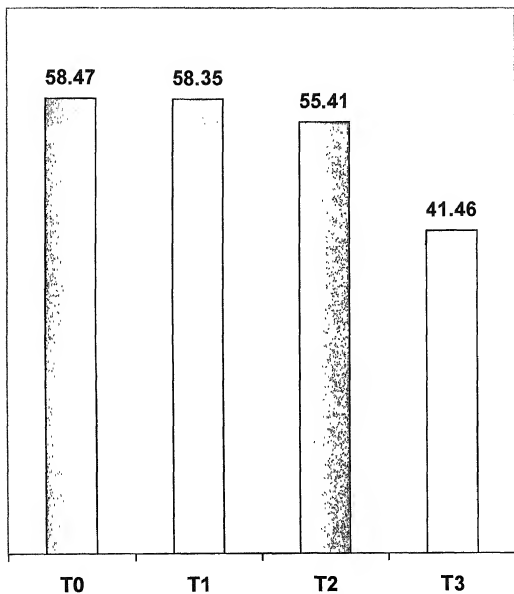
Averages free fat percentage of experimental and control Sandesh.

Sl. No.	T <sub>0</sub>	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>
1	60.32	59.32	55.32	40.31
2	59.17	57.53	54.67	42.32
3	58.11	58.31	55.11	41.56
4	57.17	59.11	54.32	40.15
5	57.12	58.76	56.07	42.31
6	58.76	59.37	55.17	41.07
7	57.53	58.87	54.32	42.37
8	58.29	58.19	56.39	40.58
9	59.55	58.31	57.00	41.76
10	58.75	55.76	55.76	42.22
<b>Average</b>	<b>58.47</b>	<b>58.35</b>	<b>55.41</b>	<b>41.46</b>
<b>Maximum</b>	<b>60.32</b>	<b>59.37</b>	<b>57.00</b>	<b>42.37</b>
<b>Minimum</b>	<b>57.12</b>	<b>55.76</b>	<b>54.32</b>	<b>40.15</b>

Free fat percentage of control Sandesh (T<sub>0</sub>) ranged from 57.12% to 60.32 % with an average of 58.47%. Experimental Sandesh (T<sub>1</sub>) had an average Free fat percentage of 58.35% with a minimum of 55.76% and a maximum of 59.37%. Experimental Sandesh (T<sub>2</sub>) had an average Free fat percentage of 55.41% and it ranged from 54.32% to 57.00%. Experimental Sandesh (T<sub>3</sub>) had an average Free fat percentage of 41.46% with a minimum of 40.15% and a maximum of 42.37%.

The above mentioned results have been shown in Figure No.25.

### Averages free fat percentage of experimental and control Sandesh



[Figure.25]

Data shown in Table No 70 were further analyzed by analysis of variance techniques, results of this analysis is given in Table No. 71.

**Table No. 71.**

**Analysis of variance of average scores of Free fat percentage of control and experimental Sandesh.**

Source of variation	D.F.	S.S.	M.S.S.	'F' Cal.	'F' Tab. (5%)	Result
Due to replication	9	5.67	0.63	0.54	2.96	N.S
Due to treatments	3	1968.01	656	565.51	2.96	S
Due to error	27	31.41	1.16			
<b>Total</b>	<b>39</b>	<b>2005.09</b>				

It is evident from the result of ANOVA given in the Table No 71 the variance ratio of 565.51 is greater than the Table value of F (3.27) at 5% level of significance. This indicates that there were significant differences in different treatment combination T<sub>0</sub>, T<sub>1</sub>, T<sub>2</sub>, & T<sub>3</sub>. It is concluded that there is significant difference in the Free fat percentage of different treatment combination.

The significant differences thus obtained were further analyzed statistically to find out the C.D. between and within the different combinations of control and experimental Sandesh. Results of C.D. are presented in Table No 72.

**Table No: 72.**

**Critical differences in Free fat percentage due to treatment combination of data.**

<b>Treatments</b>	<b>T<sub>0</sub> (58.47)</b>	<b>T<sub>1</sub>(58.34)</b>	<b>T<sub>2</sub>(55.41)</b>
<b>T<sub>3</sub>(41.46)</b>	17.01*	16.88*	13.95*
<b>T<sub>2</sub>(55.41)</b>	3.06*	2.93*	
<b>T<sub>1</sub>(58.34)</b>	0.13		

**C.D.=0.98**

**\*Significant at 5% level**

Table No 72. shows following variations in the moisture percentage of different treatment combinations.

The difference in mean value of T<sub>0</sub> & T<sub>1</sub> (0.13) is lower than the C.D. (0.98), therefore the difference is non-significant.

The difference in mean value between T<sub>0</sub> & T<sub>2</sub> (3.06) is higher than the C.D. (0.98), therefore the difference is significant.

The difference in mean value of T<sub>0</sub> & T<sub>3</sub> (17.01) is higher than the C.D. (0.98), therefore the difference is significant.

The difference in mean value of T<sub>1</sub> & T<sub>2</sub> (2.93) is higher than the C.D. (0.98), therefore the difference is significant.

The difference in mean value of T<sub>1</sub> & T<sub>3</sub> (16.88) is higher than the C.D. (0.98), therefore the difference is significant.

The difference in mean value of T<sub>2</sub> & T<sub>3</sub> (13.95) is higher than the C.D. (0.98), therefore the difference is significant.

## SANDESH

### Ash percentage

Table No: 73.

Average Ash percentage in experimental and control Sandesh.

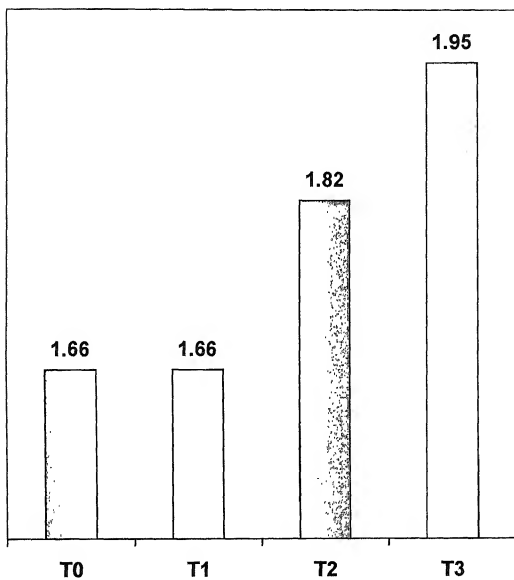
Sl. No.	T <sub>0</sub>	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>
1				
	1.45	1.73	1.87	1.95
2				
	1.75	1.62	1.75	1.96
3				
	1.65	1.73	1.83	1.93
4				
	1.62	1.41	1.85	1.89
5				
	1.58	1.53	1.89	1.88
6				
	1.67	1.69	1.71	1.97
7				
	1.73	1.71	1.93	2.01
8				
	1.67	1.64	1.93	1.99
9				
	1.69	1.72	1.72	1.97
10				
	1.82	1.87	1.81	1.98
<b>Average</b>	<b>1.66</b>	<b>1.66</b>	<b>1.82</b>	<b>1.95</b>
<b>Maximum</b>	<b>1.82</b>	<b>1.87</b>	<b>1.93</b>	<b>2.01</b>
<b>Minimum</b>	<b>1.45</b>	<b>1.41</b>	<b>1.71</b>	<b>1.93</b>

Ash percentage of control Sandesh (T<sub>0</sub>) ranged from 1.45% to 1.82 % with an average of 1.66%. Experimental Sandesh (T<sub>1</sub>) had an average ash percentage of 1.66% with a minimum of 1.41% and a maximum of 1.87%. Experimental Sandesh (T<sub>2</sub>) had an average ash percentage of 1.82% and it ranged from 1.71% to 1.93%. Experimental Sandesh (T<sub>3</sub>) had an average ash percentage of 1.95% with a minimum of 1.93% and a maximum of 2.01%.

The above mentioned results have been shown in Figure No.26.



### Average Ash percentage in experimental and control Sandesh



[Figure.26]

Data shown in Table No.73 were further analyzed by analysis of variance techniques, results of this analysis is given in Table No.74.

**Table No. 74.**

**Analysis of variance of average scores of Ash percentage of control and experimental Sandesh.**

Source of variation	D.F.	S.S.	M.S.S.	'F' Cal.	'F' Tab. (5%)	Result
Due to replication	9	0.46	0.051	3.76	2.96	S
Due to treatments	3	0.59	0.19	14.50	2.96	S
Due to error	27	0.36	0.013			
<b>Total</b>	<b>39</b>	<b>1.41</b>				

It is evident from the result of ANOVA given in the Table No 74 the variance ratio of 14.50 is greater than the Table value of F (3.27) at 5% level of significance. This indicates that there were significant differences in different treatment combination  $T_0$ ,  $T_1$ ,  $T_2$ , &  $T_3$ . It is concluded that there is significant difference in the ash percentage of different treatment combination.

The significant differences thus obtained were further analyzed statistically to find out the C.D. between and within the different combinations of controlled and filled sandesh. Results of C.D. are presented in Table No 75.

**Table No: 75.**

**Critical differences in Ash percentage due to treatment combination of data.**

<b>Treatments</b>	<b>T<sub>0</sub> (1.66)</b>	<b>T<sub>1</sub>(1.66)</b>	<b>T<sub>2</sub>(1.82)</b>
<b>T<sub>3</sub>(1.95)</b>	0.29*	0.29*	0.13*
<b>T<sub>2</sub>(1.82)</b>	0.16*	0.16*	
<b>T<sub>1</sub>(1.66)</b>	0.0		

**C.D.=0.10**

**\*Significant at 5% level**

Table No 75 shows following variations in the Ash percentage of different treatment combinations.

The difference in mean value of T<sub>0</sub> & T<sub>1</sub> (0.0) is lower than the C.D. (0.10), therefore the difference is non-significant.

The difference in mean value between T<sub>0</sub> & T<sub>2</sub> (0.16) is higher than the C.D. (0.10), therefore the difference is significant.

The difference in mean value of T<sub>0</sub> & T<sub>3</sub> (0.29) is higher than the C.D. (0.10), therefore the difference is significant.

The difference in mean value of T<sub>1</sub> & T<sub>2</sub> (0.16) is higher than the C.D. (0.10), therefore the difference is significant.

The difference in mean value of T<sub>1</sub> & T<sub>3</sub> (0.29) is higher than the C.D. (0.10), therefore the difference is significant.

The difference in mean value of T<sub>2</sub> & T<sub>3</sub> (0.13) is higher than the C.D. (0.10), therefore the difference is significant.

## Sandesh:

**Yield Percentage:**

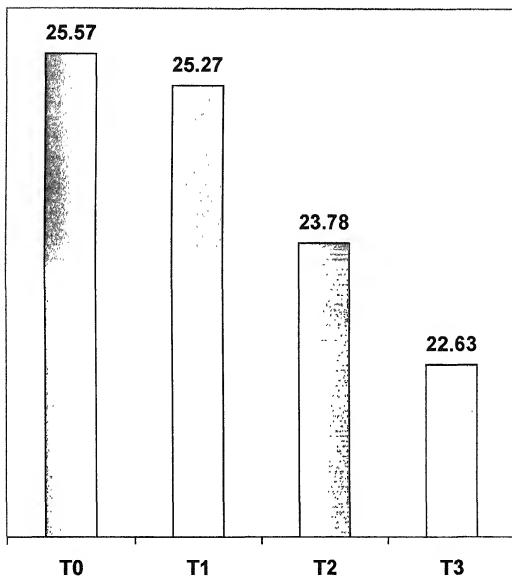
**Table No.76.**

**Average yield percentage of control and experimental Sandesh.**

Sl. No.	T <sub>0</sub>	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>
1	25.50	24.70	23.70	22.10
2	25.20	25.50	24.00	22.40
3	25.20	25.30	24.10	23.10
4	25.30	25.30	23.90	22.20
5	26.10	25.10	23.50	22.20
6	25.30	24.50	23.20	21.90
7	25.20	25.30	24.10	23.00
8	25.30	25.80	23.70	23.30
9	26.10	25.50	23.30	22.90
10	26.50	25.70	24.20	22.70
<b>Average</b>	<b>25.57</b>	<b>25.27</b>	<b>23.78</b>	<b>22.63</b>
<b>Minimum</b>	<b>25.20</b>	<b>24.50</b>	<b>23.20</b>	<b>21.90</b>
<b>Maximum</b>	<b>26.50</b>	<b>25.80</b>	<b>24.20</b>	<b>23.30</b>

Yield percentages of control sandesh (T<sub>0</sub>) ranged from 25.20% to 26.50% with an average of 25.57%. Experimental sandesh (T<sub>1</sub>) had an average of 25.27% yield with a minimum of 24.50% and a maximum of 25.80%. Experimental sandesh (T<sub>2</sub>) had an average of 23.78% yield and it ranged from 23.20% to 24.20%. Experimental sandesh (T<sub>3</sub>) had an average of 22.63% yield, with a minimum of 21.90% and a maximum of 23.30%. The above mentioned results have been shown in Figure No.27.

### Average yield percentage of control and experimental Sandesh



[Figure.27]

Data shown in Table No.76 were further analyzed by analysis of variance techniques, results of this analysis is given in Table No.77.

**Table No. 77.**

**Analysis of variance of average scores of Yield percentage of control and experimental Sandesh.**

Source of variation	D.F.	S.S.	M.S.S.	'F' Cal.	'F' Tab. (5%)	Result
Due to replication	9	3.22	0.35	2.5	2.96	S
Due to treatments	3	56.12	18.70	133.57	2.96	S
Due to error	27	4.03	0.14			
<b>Total</b>	<b>39</b>	<b>63.36</b>				

It is evident from the result of ANOVA given in the Table 77; the variance ratio of 133.57 was greater than the Table value of F (3.27) at 5% level of significance. This indicates that there were significant differences in different treatment combination  $T_0$ ,  $T_1$ ,  $T_2$ , &  $T_3$ . It is concluded that there was significant difference in the moisture percentage of different treatment combination.

The significant differences thus obtained were further analyzed statistically to find out the C.D. between and within the different combinations of control and filled Khoa. Result of C.D. is presented in Table No.78.

**Table No: 78.**

**Critical differences in Yield percentage due to treatment combination of data.**

<b>Treatments</b>	<b>T<sub>0</sub> (25.57)</b>	<b>T<sub>1</sub>(25.27)</b>	<b>T<sub>2</sub>(23.78)</b>
<b>T<sub>3</sub>(22.63 )</b>	2.94*	2.64*	1.15*
<b>T<sub>2</sub>(23.78)</b>	1.79*	1.49*	
<b>T<sub>1</sub>(25.27)</b>	0.30		

**C.D.=3.52**

**\*Significant at 5% level**

Table no 78, shows following variations in the yield percentage of different treatment combinations.

The difference in mean value of T<sub>0</sub> & T<sub>1</sub> (0.30) is lower than the C.D. (3.52), therefore the difference is non-significant.

The difference in mean value between T<sub>0</sub> & T<sub>2</sub> (1.79) is higher than the C.D. (3.52), therefore the difference is significant.

The difference in mean value of T<sub>0</sub> & T<sub>3</sub> (2.94) is higher than the C.D. (3.52), therefore the difference is significant.

The difference in mean value of T<sub>1</sub> & T<sub>2</sub> (1.49) is higher than the C.D. (3.52), therefore the difference is significant.

The difference in mean value of T<sub>1</sub> & T<sub>3</sub> (2.64) is higher than the C.D. (3.52), therefore the difference is significant.

The difference in mean value of T<sub>2</sub> & T<sub>3</sub> (1.15) is higher than the C.D. (3.52), therefore the difference is significant.

# ORGANOLEPTIC EVALUATION

## SANDESH

### Colour and appearance scores

Table No: 79.

Averages colour and appearance scores of experimental and control Sandesh.

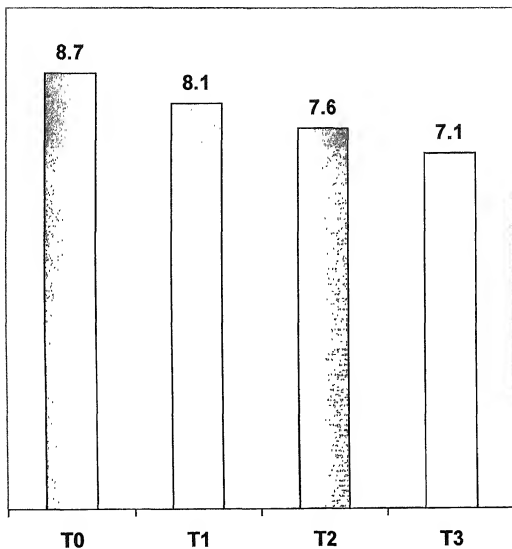
Sl. No.	T <sub>0</sub>	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>
1	8	8	7	7
2	8	8	7	7
3	9	8	8	7
4	9	8	8	7
5	9	8	8	7
6	8	8	7	6
7	9	8	8	8
8	9	8	7	8
9	9	8	8	8
10	9	9	8	6
<b>Average</b>	<b>8.7</b>	<b>8.1</b>	<b>7.6</b>	<b>7.1</b>
<b>Maximum</b>	<b>9</b>	<b>9</b>	<b>8</b>	<b>8</b>
<b>Minimum</b>	<b>8</b>	<b>8</b>	<b>7</b>	<b>6</b>

Colour and appearance scores of control Sandesh T<sub>0</sub> ranged from 8.0 to 9.0 with an average of 8.7. Experimental Sandesh T<sub>1</sub> had an average colour & appearance score of 8.1 with a minimum of 8.0 and a maximum of 9.0. Experimental Sandesh T<sub>2</sub> had an average colour and appearance score of 7.6 and it ranged from 7.0 to 8.0. Experimental Sandesh T<sub>3</sub> had an average colour and appearance score of 7.1 with a minimum of 6.0 and a maximum of 8.0.

The above mentioned results have been shown in Figure No.29.



**Averages colour and appearance  
scores of experimental and  
control Sandesh**



**[Figure.28]**

Data shown in Table No.79 were further analyzed by analysis of variance techniques, results of this analysis is given in Table No.80.

**Table No. 80.**

**Analysis of variance of average scores of colour and appearance of control and experimental Sandesh.**

Source of variation	D.F.	S.S.	M.S.S.	'F' Cal.	'F' Tab. (5%)	Result
Due to replication	9	4.12	0.45	2.00	2.96	S
Due to treatments	3	14.08	4.69	20.54	2.96	S
Due to error	27	6.17	0.22			
<b>Total</b>	<b>39</b>	<b>24.37</b>				

It is evident from the result of ANOVA given in the Table No 80 the variance ratio of 20.54 is greater than the Table value of F (3.27) at 5% level of significance. This indicates that there were significant differences in different treatment combination T<sub>0</sub>, T<sub>1</sub>, T<sub>2</sub>, & T<sub>3</sub>. It is concluded that there is significant difference in the colour and appearance scores of different treatment combination.

The significant differences thus obtained were further analyzed statistically to find out the C.D. between and within the different combinations of controlled and filled Sandesh. Results of C.D. are presented in Table No 81.

**Table No: 81.**

**Critical differences in colour and appearance scores due to treatment combination of data.**

Treatments	T <sub>0</sub> (8.7)	T <sub>1</sub> (8.1)	T <sub>2</sub> (7.4)
T <sub>3</sub> (7.1)	16*	10*	5*
T <sub>2</sub> (7.4)	11*	5*	
T <sub>1</sub> (8.1)	6		

**C.D.=0.43**

**\*Significant at 5% level**

Table No 81 shows following variations in the body & texture scores of different treatment combinations.

The difference in mean value of T<sub>0</sub> & T<sub>1</sub> (6) is lower than the C.D. (0.43), therefore the difference is non-significant.

The difference in mean value between T<sub>0</sub> & T<sub>2</sub> (11) is higher than the C.D. (0.43), therefore the difference is significant.

The difference in mean value of T<sub>0</sub> & T<sub>3</sub> (16) is higher than the C.D. (0.43), therefore the difference is significant.

The difference in mean value of T<sub>1</sub> & T<sub>2</sub> (5) is higher than the C.D. (0.43), therefore the difference is significant.

The difference in mean value of T<sub>1</sub> & T<sub>3</sub> (10) is higher than the C.D. (0.43), therefore the difference is significant.

The difference in mean value of T<sub>2</sub> & T<sub>3</sub> (5) is higher than the C.D. (0.43), therefore the difference is significant.

## SANDESH

### Body and Texture Scores

**Table No: 82.**

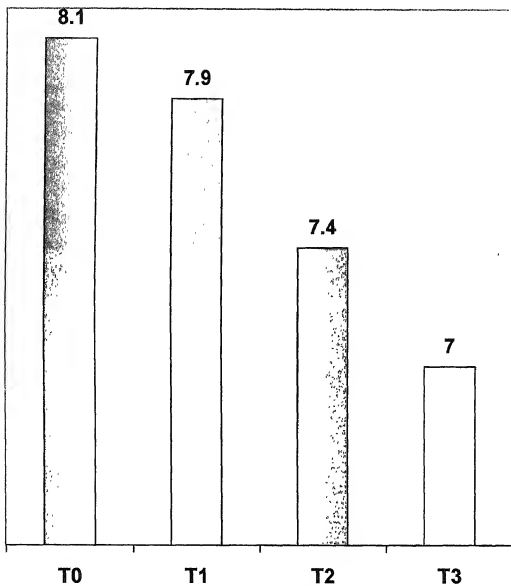
**Average Body and Texture Scores of control and experimental.**

Sl. No.	T <sub>0</sub>	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>
1	8	8	7	7
2	8	8	7	7
3	8	8	7	7
4	8	7	7	7
5	8	8	8	7
6	9	8	7	7
7	8	8	8	7
8	8	8	8	7
9	8	8	7	7
10	8	8	8	7
<b>Average</b>	<b>8.1</b>	<b>7.9</b>	<b>7.4</b>	<b>7</b>
<b>Minimum</b>	<b>9</b>	<b>8</b>	<b>8</b>	<b>7</b>
<b>Maximum</b>	<b>7</b>	<b>7</b>	<b>7</b>	<b>7</b>

Body & texture scores of control Sandesh T<sub>0</sub> ranged from 7 to 9 with an average of 8.1. Experimental Sandesh T<sub>1</sub> had an average body & texture score of 7.9 with a minimum of 7 and a maximum of 8. Experimental sandeshT<sub>2</sub> had an average body & texture score of 7.4 and it ranged from 1.71 to 1.93. Experimental sandeshT<sub>3</sub> had an average body & texture score of 7 with a minimum of 7 and a maximum of 7.

The above mentioned results have been shown in Figure No.28.

# Average Body and Texture Scores of control and experimental



[Figure.29]

Data shown in Table No.82 were further analyzed by analysis of variance techniques, results of this analysis is given in Table No. 83.

**Table No. 83.**

**Analysis of variance of average scores of body & texture of control and experimental Sandesh.**

Source of variation	D.F.	S.S.	M.S.S.	'F' Cal.	'F' Tab. (5%)	Result
Due to replication	9	1.1	0.122	0.982	2.96	S
Due to treatments	3	7.4	2.46	21.57	2.96	S
Due to error	27	3.1	0.114			
<b>Total</b>	39	11.6				

It is evident from the result of ANOVA given in the Table No 83 the variance ratio of 21.57 is greater than the Table value of F (3.27) at 5% level of significance. This indicates that there were significant differences in different treatment combination  $T_0$ ,  $T_1$ ,  $T_2$ , &  $T_3$ . It is concluded that there is significant difference in the body & texture scores of different treatment combination.

The significant differences thus obtained were further analyzed statistically to find out the C.D. between and within the different combinations of controlled and filled Sandesh. Results of C.D. are presented in Table No 84.

**Table No: 84.**

**Critical differences in Body & Texture scores due to treatment combination of data.**

Treatments	T <sub>0</sub> (8.1)	T <sub>1</sub> (7.9)	T <sub>2</sub> (7.4)
T <sub>3</sub> (7.0)	11*	9*	4*
T <sub>2</sub> (7.4)	7*	5*	
T <sub>1</sub> (7.9)	2		

**C.D.=0.30**

**\*Significant at 5% level**

Table No 84 shows following variations in the body & texture scores of different treatment combinations.

The difference in mean value of T<sub>0</sub> & T<sub>1</sub> (2) is lower than the C.D. (0.30), therefore the difference is non-significant.

The difference in mean value between T<sub>0</sub> & T<sub>2</sub> (7) is higher than the C.D. (0.30), therefore the difference is significant.

The difference in mean value of T<sub>0</sub> & T<sub>3</sub> (11) is higher than the C.D. (0.30), therefore the difference is significant.

The difference in mean value of T<sub>1</sub> & T<sub>2</sub> (5) is higher than the C.D. (0.30), therefore the difference is significant.

The difference in mean value of T<sub>1</sub> & T<sub>3</sub> (9) is higher than the C.D. (0.30), therefore the difference is significant.

The difference in mean value of T<sub>2</sub> & T<sub>3</sub> (4) is higher than the C.D. (0.30), therefore the difference is significant.

## **SANDESH**

### **Flavour Scores**

**Table No: 85.**

**Average flavour scores of experimental and control Sandesh**

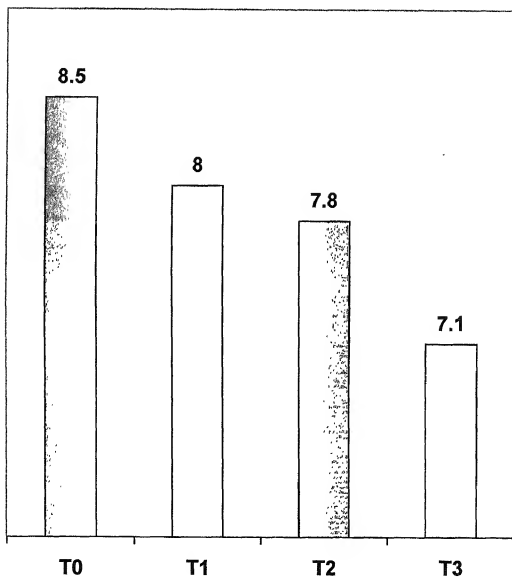
<b>Sl. No.</b>	<b>T<sub>0</sub></b>	<b>T<sub>1</sub></b>	<b>T<sub>2</sub></b>	<b>T<sub>3</sub></b>
1	9	8	8	7
2	8	8	7	7
3	9	8	8	7
4	8	8	8	7
5	8	8	8	7
6	9	8	8	7
7	9	8	8	7
8	8	8	7	7
9	8	8	8	7
10	9	8	8	8
<b>Average</b>	<b>8.5</b>	<b>8</b>	<b>7.8</b>	<b>7.1</b>
<b>Minimum</b>	<b>9</b>	<b>8</b>	<b>8</b>	<b>8</b>
<b>Maximum</b>	<b>8</b>	<b>8</b>	<b>7</b>	<b>7</b>

Flavour scores of control Sandesh T<sub>0</sub> ranged from 8 to 9 with an average of 8.5. Experimental Sandesh T<sub>1</sub> had an average flavour score of 8 with a minimum of 8 and a maximum of 8. Experimental Sandesh T<sub>2</sub> had an average flavour score of 7.8 and it ranged from 7 to 8. Experimental Sandesh T<sub>3</sub> had an average flavour score of 7.1 with a minimum of 7 and a maximum of 8.

The above mentioned results have been shown in Figure No.29.



### Average flavour scores of experimental and control Sandesh



[Figure.30]

Data shown in Table No.85 were further analyzed by analysis of variance techniques, results of this analysis is given in Table No. 86.

**Table No: 86.**

**Analysis of variance of average scores of flavour of control and experimental Sandesh.**

Source of variation	D.F.	S.S.	M.S.S.	'F' Cal.	'F' Tab. (5%)	Result
Due to replication	9	2.1	0.23	2.09	2.96	S
Due to treatments	3	10.1	3.37	30.6	2.96	S
Due to error	27	2.9	0.11			
<b>Total</b>	<b>39</b>	<b>15.1</b>				

It is evident from the result of ANOVA given in the Table No 86 the variance ratio of 30.6 is greater than the Table value of F (3.27) at 5% level of significance. This indicates that there were significant differences in different treatment combination T<sub>0</sub>, T<sub>1</sub>, T<sub>2</sub>, & T<sub>3</sub>. It is concluded that there is significant difference in the flavour scores of different treatment combination.

The significant differences thus obtained were further analyzed statistically to find out the C.D. between and within the different combinations of controlled and filled Sandesh. Results of C.D. are presented in Table No 87.

**Table No: 87.**

**Critical differences in flavour percentage due to treatment combination of data.**

Treatments	T <sub>0</sub> (8.5)	T <sub>1</sub> (8.0)	T <sub>2</sub> (7.8)
T <sub>3</sub> (7.1)	14*	9*	7*
T <sub>2</sub> (7.8)	7*	2*	
T <sub>1</sub> (8.0)	5		

**C.D.=0.30**

**\*Significant at 5% level**

Table No 87 shows following variations in the body & texture scores of different treatment combinations.

The difference in mean value of T<sub>0</sub> & T<sub>1</sub> (5) is lower than the C.D. (0.30), therefore the difference is non-significant.

The difference in mean value between T<sub>0</sub> & T<sub>2</sub> (7) is higher than the C.D. (0.30), therefore the difference is significant.

The difference in mean value of T<sub>0</sub> & T<sub>3</sub> (14) is higher than the C.D. (0.30), therefore the difference is significant.

The difference in mean value of T<sub>1</sub> & T<sub>2</sub> (2) is higher than the C.D. (0.30), therefore the difference is significant.

The difference in mean value of T<sub>1</sub> & T<sub>3</sub> (9) is higher than the C.D. (0.30), therefore the difference is significant.

The difference in mean value of T<sub>2</sub> & T<sub>3</sub> (7) is higher than the C.D. (0.30), therefore the difference is significant.

# ECONOMICS OF PRODUCTION

## Peda

The economics of the peda has been worked on the basis of the equal level of the fat percentage in the original milk. Since the control peda (To) has been made from khoa prepared from buffalo milk having 6% fat, so to compare the cost of production, the experimental peda (T1) with 6% vegetable fat was taken to work out the economics. The following table gives a clear picture of the comparison of the cost of the production, the peda made from vegetable fat worked out to be 51% cheaper than the peda made from buffalo milk.

	<b>Filled Milk Vegetable Fat (6%)</b>	<b>Buffalo Milk Milk Fat (6%)</b>
<b>For 100 litres</b>		
<b>Raw material</b>		
Skim milk @ Rs.6 per lit		
For 96.5 litres	579.00	
Buffalo milk @ Rs.15 per lit		
For 100 litres		1500.00
Vegetable Oil @ Rs.36 per kg		
For 3.5 kg	126.00	
Sugar @ Rs.18 per kg		
For 7.5 kg	135.00	135.00
<b>Processing cost @ 30% of Raw material</b>	252.00	491.00
<b>Total cost</b>	<b>1092.00</b>	<b>2126.00</b>
<b>Cost per piece</b>	<b>0.91</b>	<b>1.77</b>

## Sandesh

The economics of the sandesh has been worked on the basis of the equal level of the fat percentage in the original milk. Since the control sandesh (To) has been made from khoa prepared from cow milk having 6% fat, so to compare the cost of production, the experimental sandesh (T1) with 6% vegetable fat was taken to work out the economics. The following table gives a clear picture of the comparison of the cost of the production, the sandesh made from vegetable fat worked out to be 51% cheaper than the sandesh made from cow milk.

	<b>Filled Milk Vegetable Fat (4%)</b>	<b>Cow Milk Milk Fat (4%)</b>
<b>For 100 litres</b>		
<b>Raw material</b>		
Skim milk @ Rs.6 per lit		
For 98.9 litres	593.4	
Cow milk @ Rs.12 per lit		
For 100 litres		1200.00
Vegetable Oil @ Rs.36 per kg		
For 1.0 kg	36.00	
Sugar @ Rs.18 per kg		
For 7.5 kg	135.00	135.00
Muslin Cloth @ Rs. 11Per meter		
For 3.0 metre	33.00	33.00
Citric Acid @ Rs.180 Per kg		55.55
For 200 gm	55.55	
<b>Processing cost @ 30% of Raw material</b>	255.88	690.00
<b>Total cost</b>	<b>1108.43</b>	<b>2113.55</b>
<b>Cost per piece</b>	<b>0.92</b>	<b>1.76</b>

# CHAPTER-V

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Summary and Conclusion

## SUMMARY AND CONCLUSION

The present investigation "Studies on the utilization of Filled Milk for the preparation of Indigenous Milk Product (Khoa & Chhana) and thereafter their Sweets (Peda & Sandesh)" was planned and carried out in the Department of Dairy Technology, Allahabad Agricultural Institute, Allahabad.

The present study was an attempt to find out the feasibility of manufacturing Khoa & Chhana from Filled Milk and then preparing sweets namely Peda & Sandesh.

The present investigation was carried out with the following objectives.

1. To develop suitable technology for the preparation of filled Khoa and Chhana.
2. To develop appropriate technology for preparing Filled Peda and Sandesh.
3. To study the chemical quality of filled Khoa and Chhana.
4. To study the chemical and organoleptic quality of Filled Peda and Sandesh.
5. To study the economics of the products prepared.

The experiment was conducted in the Research Laboratory of the Department of Dairy Technology, Allahabad Agricultural Institute, Allahabad. The different treatments replicated in this study were

### **Control Khoa**

T<sub>0</sub> - Khoa prepared from Buffalo milk with 6% fat and 9% s.n.f.

### **Experimental Khoa**

T<sub>1</sub> - Khoa prepared from filled milk standardised to 6% fat and 9% s.n.f.

T<sub>2</sub> - Khoa prepared from filled milk standardised to 5% fat and 9% s.n.f.

T<sub>3</sub> - Khoa prepared from filled milk standardised to 4% fat and 9% s.n.f.

### **Control Peda**

T<sub>0</sub> - Peda was prepared from control Khoa (T<sub>0</sub>)

### **Experimental Peda**

T<sub>1</sub> - Peda was prepared from experimental Khoa (T<sub>1</sub>)

T<sub>2</sub> - Peda was prepared from experimental Khoa (T<sub>2</sub>).

T<sub>3</sub> - Peda was prepared from experimental Khoa (T<sub>3</sub>).

### **Control Chhana**

T<sub>0</sub> - Chhana prepared from Cow milk with 4% fat and 8.5% SNF.

### **Experimental Chhana**

- T<sub>1</sub> - Chhana prepared from filled milk standardised to 4% fat and 8.5% snf.  
T<sub>2</sub> - Chhana prepared from filled milk standardised to 3% fat and 8.5% snf.  
T<sub>3</sub> - Chhana prepared from filled milk standardised to 2% fat and 8.5% snf.

### **Control Sandesh**

- T<sub>0</sub> - Sandesh was prepared from control Chhana (T<sub>0</sub>)

### **Experimental Sandesh**

- T<sub>1</sub> - Sandesh was prepared from experimental Chhana (T<sub>1</sub>)  
T<sub>2</sub> - Sandesh was prepared from experimental Chhana (T<sub>2</sub>).  
T<sub>3</sub> - Sandesh was prepared from experimental Chhana (T<sub>3</sub>).

The Products were evaluated organoleptically by a panel of five Judges drawn from the faculty of Department of Dairy Technology and chemically analysed for the following parameters.

#### **1. Khoa**

- a. Moisture percentage.
- b. Fat percentage.
- c. Protein percentage.
- d. Lactose percentage.

#### **2. Peda**

- a. Moisture percentage.
- b. Fat percentage.
- c. Protein percentage.
- d. Lactose percentage.
- e. Total Sugar percentage.
- f. Ash percentage.
- j. Free Fat percentage.

#### **3. Chhana**

- a. Moisture percentage.
- b. Fat percentage.



c. Protein percentage.

#### **4. Sandesh**

a. Moisture percentage.

b. Fat percentage.

c. Protein percentage.

d. Total Sugar percentage

e. Ash percentage

f. Free Fat percentage

Both Peda and Sandesh were organoleptically evaluated for

a. Colour and Appearance

b. Body and Texture

c. Flavour

by a panel of five Judges drawn from the faculty of Department of Dairy Technology, Allahabad Agricultural Institute.

The four treatments for each product were replicated ten times and data obtained from the above test were statistically analysed using analysis of variance technique and critical difference. The observation recorded during entire experimental period reveal the following summary of the findings and subsequent conclusion.

#### **Khoa**

##### **a. Moisture percentage**

There was significant difference in the moisture percentage of different treatment combination. This may be attributed to the varying fat percentage in the milk. It was observed that as the fat percentage in milk increased, there was an increase in the moisture. Experimental Khoa (T3) with 4% vegetable fat showed the highest moisture percentage. The moisture content of khoa is a very variable factor and cannot be easily controlled by the method of preparation.

##### **c. Fat percentage**

Significant differences were observed in the different treatment combination between the fat percentage of control and experimental Khoa.

This is attributed to the initial quality of milk, where experiments were conducted with different fat percentage in the milk. It was observed that as the fat percentage in the milk increased the fat percentage in Khoa also increased. Variation in the fat percentage of khoa is largely determined by the fat level in milk and degree of concentration effected. Similar results were also observed by Iyer (1948), Sethana & Bhat(1949) and Rajorhia (1991) and Zariwalla(1974).

**c. Protein percentage**

Significant differences were observed in the protein percentage between control and experimental Khoa. Experimental khoa (T3) showed the highest protein percentage and the lowest protein percentage was shown by (T0) control khoa. It was observed that as the fat percentage in the milk increased the protein percentage in khoa decreased.

**d. Lactose percentage**

It was observed that there was no significant difference in the lactose percentage between control and experimental Khoa.

**e. Yield percentage**

Significant difference was observed in yield percentage of different treatment combination of control and experiment Khoa. It was found that as the fat percentage in the initial milk increased the yield of khoa also increased.

**Peda**

**a. Moisture percentage**

Significant difference was observed in the moisture content in different treatment combination of Peda. Peda was prepared from samples of khoa, where significant difference in moisture was observed. The process of peda manufacture required further heating causing more moisture to be evaporated with the result that the moisture percentage in peda was less as compared to moisture percentage of khoa, from which peda was manufactured.

**b. Fat percentage**

Significant difference was observed in the fat content in different treatment combination of control and experimental peda. It was observed that since khoa samples with varying fat percentage was used as the base material for peda manufacture it was, but obvious that the fat percentage in peda would differ significant.

**c. Protein percentage**

There was significant difference in the protein percentage of peda of different treatment combination of control and experimental peda. It was observed that the protein percentage in peda showed lower value as the fat percentage in khoa increased.

**d. Lactose percentage**

No significant difference was observed in the lactose percentage of the different treatment combination of the control and experimental peda. It was observed that the varying fat percentage of the initial quality of milk did not have a significant influence on the lactose percentage of peda.

**e. Total sugar percentage**

Significant difference was observed in the total sugar percentage in different treatment combination of control and experimental peda.

**f. Ash percentage**

No significant difference was observed in the ash percentage of different treatment combination of control and experimental peda. The varying fat percentage in the khoa samples from which peda has been prepared did not have any effect on the ash percentage of peda.

**g. Free fat percentage**

Significant difference was observed in the free fat content in different treatment combination of control and experimental peda. It was observed that as the fat percentage in khoa increased the free fat content also increased. This could be presumed from the fact that as the fat percentage increased the number of fat globules present per unit also increased. The fat globule membrane ruptures, due to combined action of scraping and agitation and releases free fat. The higher the fat percentage in peda, the larger the free fat content and vice versa. Ranganadham and Rajorhia (1989) also made similar observation

**h. Yield percentage**

Significant difference was observed in different treatment combination of control and experimental peda. It was found that the yield increased as the fat percentage in khoa increased. The yield is influenced by total solids in milk and the moisture content in the final product. Rajorhia (1971) and De & Ray (1952) observed similar results

## Organoleptic Evaluation

### a. **Body and Texture scores.**

Significant differences in body and texture scores in different treatment combination of control and experimental samples were observed. It was found that peda prepared by milk fat (T0) was most preferred, it had coarse and grainy texture and the product was of soft mouthfeel, however (T1) vegetable fat peda though it scored well but, it had a hard body and also had slightly less coarse and grainy texture, the peda was of more white in colour. Peda prepared from (T2) was harder and rough, while (T3) peda was not only hard but was sticky and rubbery in mouth.

### b. **Colour and Appearance scores**

Significant difference was observed in colour and appearance in different treatment combination of control and experimental samples. Experimental peda had whitish colour while control peda was more of yellowish brown colour.

### c. **Flavour scores**

Significant difference was observed in the flavour in different treatment combination of control and experimental samples.

## **Chhana**

### a. **Moisture percentage**

Significant difference was observed in the moisture percentage of different treatment combination of control and experimental chhana. It was observed that as the fat percentage in initial milk increased, the moisture percentage also increased. **Rajorhia and Sen (1988)** reported wide variation in the moisture content of chhana ranging from 48% to 62.3%, surprisingly not a single chhana samples approached the higher moisture limit as presented under the P.F.A.rules. (i.e. 70% moisture).

### b. **Fat percentage**

Significant difference was observed in the fat percentage of different treatment combination of control and experimental chhana. It was observed that as the fat percentage increased in the initial milk, the fat percentage in chhana also increased.

**c. Protein percentage**

Significant difference was observed in the protein percentage of different treatment combination of control and experimental chhana. It was observed that as the fat percentage increased the protein percentage decreased.

**d. Yield percentage**

Significant difference was observed in the different treatment combination of control and experimental chhana. It was observed that as the fat percentage in the initial milk increased the yield also increased.

**Sandesh**

**a. Moisture percentage**

Significant difference was observed in the moisture percentage of different treatment combination of control and experimental chhana. It was observed that as the fat percentage increased the moisture percentage decreased.

**b. Fat percentage**

Significant difference was observed in the fat percentage in different treatment combination of control and experimental sandesh. It was observed that as the fat percentage increased the fat percentage of sandesh also increased. As the fat content in filled chhana increased there was an improvement in the flavour and body and texture scores. It is well-established fact that fat contributes to the richness of the products. Chawla (1987) and Roy and Singh (1999) also found similar results.

**c. Protein percentage.**

Significant difference was observed in the protein percentage of different treatment combination of control and experimental sandesh. It was observed that as the fat percentage increased the protein percentage decreased.

**d. Total sugar percentage**

Significant difference was observed in the total sugar percentage of different treatment combination of control and experimental sandesh.

**e. Free fat percentage**

Significant difference was observed in the free fat percentage of different treatment combination of the control and experimental sandesh. It was observed that as the fat percentage increased the percentage of free fat also increased.

**f. Ash percentage**

Significant difference was observed in the ash percentage of different treatment combination of control and experimental sandesh. It was observed that as the fat percentage increased the ash percentage decreased.

**g. Yield percentage**

Significant difference was observed in the different treatment combination of control and experimental sandesh. Since sandesh was prepared from different of chhana, it was but obvious that significant difference was observed. The yield is due to the combined action of added sugar and the higher moisture and milk solids retention in sandesh.

**Organoleptic Evaluation**

**a. Body and texture**

Significant difference was observed in the body and texture scores of control and experimental sandesh. Control sandesh (T0) had soft body and smooth texture. Experimental sandesh (T1) had slightly hard body and less smooth texture than the control sandesh. The other experimental sandesh (T2 & T3) were dry, and coarse textured.

**b. Colour and Appearance**

Significant difference was observed in the colour and appearance scores of control and experimental sandesh.

**c. Flavour**

Significant difference was observed in the flavour scores of control and experimental sandesh.

## Conclusion

Attempts were made to develop filled khoa and filled chhana and then converting filled khoa into peda and filled chhana into sandesh. Effect of fat level (4,5,6, %) for khoa and peda manufacture and (2,3,4%) for chhana and sandesh manufacture revealed that higher the fat level in filled milk better was the products. It was found that quite acceptable products were made from filled milk

Significant differences were found in moisture, fat, protein and yield percentage of khoa, while lactose did not differ significantly. Significant difference were found in moisture, fat, protein, Total sugar, free fat and yield percentage in peda while non significant difference were found in lactose, ash percentage.

Significant differences were found in moisture, fat, protein and yield percentage of chhana. Significant difference were found in moisture, fat, protein, Total sugar, free fat, ash and yield percentage in sandesh.

It was found that since the fat percentage in the initial milk of the experimental samples varied so it became obvious that significant difference in the physico chemical aspects of khoa and chhana and in their sweets peda and sandesh were observed. This is an indication that quality of milk does play a role, but not the type of milk. In other words it mean that the type of milk (filled milk) does not have a significant role in the chemical

quality of the product manufactured. This however does not hold true, when the organoleptic evaluation was done on peda and sandesh. It was found that significant differences were found in colour and appearance, body and texture and flavour, both in Peda and Sandesh.

The cost of production was also found and the conclusion drawn is that filled milk products are 48-55% cheaper than the product manufactured from pure milk.

**Recommendation:** - Systematic rheological and microbiological studies on the filled milk khoa and chhana and their sweets peda and sandesh will be of interest.

# CHAPTER-VI



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# ANNEXURE

# ANNEXURE I

A panel of five judges using a 9- point hedonic scale did sensory evaluation of the products. The same score card was used for Khoa, Chhana, Peda and Sandesh

## Score card

Name of the Judge: -

Replication No: -

Please place score opposite the rating for perfect score and the defects observed might be expressed critically in the column of remarks.

Guidelines:

Examine the colour and appearance of the products

Examine the body and texture of the products

Examine the flavour of the products

Hedonic Rating	Score
Excellent	9
Very good	8
Good	7
Fair	6
Neither good and bad	5
Slightly undesirable	4
Poor	3
Very poor	2
Unacceptable	1

ATTRIBUTES	TREATMENTS			
	T0	T1	T2	T3
Colour and appearance				
Body and texture				
Flavour and taste				

Dated

Signature

# ANNEXURE II

## List of Abbreviation

%	-Percent
/	-Per
@	-at the rate of
ANOVA	-Analysis of variance
Approx.	-Approximate
aw	-Water activity
BHA	-
BM	-Buffalo milk
C.D	-Critical difference
CFU	-Colony forming units
Cm	-Centimeter
Cm <sup>2</sup>	-Centimeter square
d.f.	-Degree of freedom
D.F.M	-Dried filled milk
DM	-Dry Matter
EEC	-European economic countries
e.g.	-exempli gratia, for example
ERH	-Equilibrium relative humidity
<i>et.al</i>	-et alibi, and others
F (cal)	-Calculated "F" value
F (Tab)	-"F" Table value
FAO	-Food Agriculture organisation
FFA	-Free fatty acid
Fig	-Figure
FMB	-Filled milk beverages
G.C	-
Gal	-gallon
Gm	-Gram
h	-Hour
h	-hours

i.e	-that is
in-2	-inches square
ISI	-Indian Standard Institution
ISSHE	-Inclined scraped surface heat exchange
I.U	-International units
Kcal	-Kilo calories
kg.	-Kilogram
l	-Liter
lb	-Pound
LDPE	-low density polyethylene
m	-Consistency coefficient
M	-Meter
m.p	-Melting Point
M.S.S.	-Mean sum of square
Max	-Maximum
M-equiv.	-Milli-equivalent
mg	-Milligram
Min	-Minimum
Min	-minutes
n	-Flow behaviour index
N	-Nitrogen
NaCl	-Sodium Chloride
No	-Number
NPU	-Net protein utilization
°C	-Degree centigrade
°F	-Degree Farhenhight
Oz	-ounce
P.F.A	-Prevention of Food Adulteration
p.p.m	-Parts per million
P.U.F.A.	-Poly unsaturated fatty acids
PP	-Poster paper
Qty	-Quantity
Resp,	-respectively



RH	-Relative Humidity
RO	-Reverse osmosis
S.M.P	-Skim milk powder
S.S.	-Sum of square
S.V.A	-Synthetic vitamin A
SBM	•Standardized Buffalo milk
SCBM	-Sweet cream butter milk
sec	-Seconds
SM	-Skim milk
snf	-solids not fats
t	-Tonnes
T.S	-Total solids
TP	-Texture profile
w/v	-Weight by volume
w/w	-Weight by weight
WDP	-Water dispersable protein
wk	-Week
WPC	-Whey protein concentrate
wt	-Weight.